ERRATA

The Tropical Agriculturist, September, 1941, page 119, lines 14 and 15 from bottom : for "*nephantidis M. Perisierola*" read "*Perisierola nephantidis* M."

The Tropical Agriculturist, September, 1941, page 130, line 12 from bottom : for "May, 1941" read "November, 1938". The photographs of the trees were taken in May, 1941.

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Tropical Agriculturist

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EDITORIAL

THE FUTURE OF OLD COCONUT ESTATES

IN the last issue of this journal we associated ourselves with the warning sounded by the officers of the Coconut Research Scheme that, unless the older estates were replanted, production of coconuts would progressively decline, and added that failure to replant with the first signs of senility of the existing trees could be justified only by the intention to retire the land from the coconut crop. Perhaps the context and the tone of this observation give the impression that the alternative of retirement is mentioned as a development which no reasonable man would contemplate, in the same way that advice given to a motorist to observe the rules of the road unless he intends to kill himself does not admit the possibility that he could have any such intention. It would, therefore, be useful to examine whether there are any reasons for believing that all land-owners may not wish to renew their plantations.

On the basis of the fluctuating prices of the last eight years, the average annual income per acre of coconut land which may be classified as good in respect of the conditions of soil and climate, calculated as the difference between gross receipts and current cost of production and marketing, may be estimated at thirty rupees. While there will be a large number of smallholders who will continue to plant a few coconut trees each in his own compound more through inherited instinct than as an investment, it is doubtful whether a capitalist will plant coconuts in the expectation of these returns : nor can one predict with a degree of reasonable assurance that fifteen or twenty years hence even these modest returns will be obtainable. Moreover, there are two types of land which no one will want to replant—those in which the soil has been thoroughly depleted by erosion and those which may be classified as marginal or sub-marginal and to which cultivation was unwisely extended under the stimulus of the rising prices of the turn of the century. It is fairly certain that presently there will be coconut-land-owners who are in

doubt whether they should replant their old estates with a new generation of the same crop or should replace the coconut with any other crop which assures them of an annual income of Rs. 40 to Rs. 50 per acre, as well as those who find it necessary to turn away from coconuts on any terms. The Department of Agriculture appears to be the authority to which land-owners will naturally turn for advice with regard to suitable alternative crops.

The Department has hitherto done no investigational work which would qualify it to give this advice. Common observation and experience in other parts of the world leave no doubt that, unless proximity to a city or other factor makes the intensive cultivation of a very valuable crop by the artificial reformation of the soil practicable, land exhausted by erosion must revert to permanent pasture. Only experiments carefully planned and sustained over a long period can teach us to what remunerative use those lands can be put which can be regenerated without prohibitive expenditure. It may be regarded as one of the principal duties of the Department of Agriculture at the present time to launch these experiments.

THE ANALYSIS OF CEYLON FOODSTUFFS

X.—THE MINERAL ANALYSES OF SOME LOCAL YAMS AND VEGETABLES

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THIS paper deals with an investigation into the protein and mineral contents of a number of yams and green vegetables grown in Ceylon with a view to find how far such foodstuffs could supplement the average diet in regard to proteins, calcium and phosphorus. It is well known that the diet of the poorer classes of any country is invariably lacking in these dietary requisites. Yams are a popular food of the poorer section of this country and, as such, it is necessary to compare their popularity with their nutritional value.

The following figures were obtained with foodstuffs which were either bought in the markets or obtained from experimental stations :—

TABLE I

Roots

Name.	Moisture.	Ash.	Protein.	Calcium.	Phosphorus.	Magnesium.
Bathala ..	45·5..	0·57..	1·20..	0·006..	0·103..	0·016
Dehiala ..	48·5..	0·78..	3·70..	0·009..	0·123..	0·031
Karanai (T.) ..	79·9..	1·16..	0·88..	0·095..	0·050..	0·025
Hingurala ..	60·9..	0·84..	1·97..	0·001..	0·064..	0·016
King Yam (Low-country)	76·2..	0·88..	2·06..	0·002..	0·061..	0·011
King Yam (Jaffna) ..	73·7..	0·76..	2·05..	0·003..	0·062..	0·012
King Yam (Experimental Station, Jaffna) ..	55·4..	0·59..	2·65..	0·009..	0·054..	0·019
Kiriala	43·4..	0·73..	2·95..	0·009..	0·119..	0·013
Kirikondol ..	68·1..	0·75..	1·23..	0·002..	0·041..	0·015
Kukulala ..	68·7..	0·63..	1·16..	0·004..	0·041..	0·026
Manioc (Peradeniya) ..	66·9..	0·76..	0·64..	0·004..	0·041..	0·013
Manioc (Jaffna) ..	58·0..	1·06..	0·73..	0·024..	0·066..	0·021
Manioc (Jaffna Experimental Station) ..	69·9..	0·84..	0·52..	0·039..	0·034..	0·014
Yellow sweet potato ..	62·1..	1·1 ..	2·35..	0·025..	0·030..	0·036
Rathala ..	58·4..	0·65..	4·01..	0·008..	0·116..	0·017

The analytical figures shown represent percentages of fresh materials. Owing to the uncertainty of the freshness of the roots, the results, for purposes of comparison, are expressed below as percentages of the dry weight :—

TABLE II

Roots

Name.	Ash.	Protein.	Calcium.	Phosphorus.	Magnesium.
Bathala	1·04	2·2	0·011	0·188	0·029
Karanai	5·76	4·37	0·472	0·248	0·124
Dehiala	1·51	7·18	0·017	0·239	0·060
Hingurala	2·14	5·05	0·003	0·164	0·042
King Yam	3·71	8·68	0·007	0·256	0·047
Kiriala	1·3	5·21	0·016	0·211	0·023
Kirikondol	2·36	3·86	0·007	0·128	0·047
Kukulala	2·0	3·70	0·012	0·131	0·082
Manioc (Peradeniya)	2·30	1·93	0·012	0·125	0·040
Habarala	3·67	5·41	0·226	0·107	0·271
Rathala	1·60	9·75	0·019	0·282	0·041

TABLE III

Leafy Vegetables

Name.	Botanical Name.	Moisture.	Protein.	Calcium.	Magnesium.	Phosphorus.	Iron.
Arai-keerai	*Amaranthus polygonoides* L.	85·9	4·32	0·595	0·228	0·074	0·005
Kura-thampala	*Amaranthus viridis* L.	87·3	3·54	0·540	0·221	0·087	0·006
Kangun	*Ipomaea aquatica* Forsk	85·5	5·06	0·132	0·035	0·038	0·005
Mukunuvenna	*Alternanthera sessilis* R. Br.	86·2	3·30	0·226	0·101	0·049	0·006
Gas-thampala	*Amaranthus gangeticus* L.	85·2	4·32	0·517	0·218	0·092	0·007
Sarana	*Boerhaavia diffusa* L.	92·1	2·18	0·117	0·076	0·042	0·004
Kathurumurunga	*Sesbania grandiflora* Pers.	82·3	6·16	0·302	0·082	0·074	0·004

These results represent percentages of the fresh material. But here again, the freshness is a doubtful factor and for purposes of comparison, the analyses are expressed below as percentages of dry weight :—

TABLE IV

Leafy Vegetables

Name.	Protein.	Calcium.	Magnesium.	Phosphorus.	Iron.
Arai-Keerai	30·67	4·22	1·62	0·525	0·035
Kura-thampala	27·95	4·26	1·74	0·687	0·047
Kangung	34·90	0·91	0·24	0·262	0·034
Mukunuvenna	23·91	1·64	0·73	0·355	0·043
Gas-thampala	29·20	3·49	1·47	0·621	0·047
Sarana	27·60	1·48	0·96	0·531	0·050
Kathurumurunga	34·80	1·70	0·46	0·418	0·023

The methods of analysis of minerals recommended by the Rowett Institute, Aberdeen, (cf. Imperial Bureau of Animal Nutrition, Technical Communication No. 9) were employed with slight modifications.

DISCUSSION

It is interesting to compare the mineral contents of these foodstuffs with the figures of Sherman (1938) representing the daily requirements of an average adult. Such an adult

should include 0·45 gms. of calcium, 0·88 gms. of phosphorus and 12 mgs. of iron in his daily diet. It is evident that yams could hardly supply these nutritional needs, whereas green vegetables compare favourably in this respect. In fact, the biological value of a Ceylonese diet, consisting mainly of carbohydrates, could hardly be enhanced by inclusion of roots in the diet. On the other hand, the wider use of green vegetables to correct the mineral deficiency of our diet should be advocated by those interested in the nutritional problems of this country, especially because they are good sources of vitamins A and C as well. It is worth considering whether the lands at present devoted to the cultivation of yams could not be used more profitably for the cultivation of foodstuffs of greater nutritional value.

In considering the calcium content of foodstuffs, one should bear in mind the fact that the nutritional availability of calcium varies with different foods. It was found that calcium of milk was well utilized, that of kale and carrots equally well (Rose, 1920), while that of spinach was utilized to only a very slight extent if at all (Fincke, 1935). According to Fincke, oxalate in the food may greatly reduce the absorption of the food calcium and this may account for serious discrepancies in calcium balance experiments carried out with foodstuffs which were known to have a high calcium content. The availability of calcium of green vegetables should be determined by animal experiments and the results of such an investigation would be more significant than those obtained by chemical analysis.

It is not claimed that the analytical figures obtained in the present investigation represent average values for the foodstuffs concerned. In fact on comparing these values with those obtained by Koch and Kandiah (1938) and by Joachim, Kandiah and Panditesekera (1939) certain discrepancies are observed which may be attributed to sample differences. The influence of soil on the mineral content of foodstuffs is too significant to be overlooked when making up standard figures for nutritional work.

SUMMARY

Roots have no nutritional importance apart from their carbohydrate content. Green vegetables are excellent sources of calcium, iron and vitamins A and C.

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THE STORAGE OF RICE IN STEEL DRUMS

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CEYLON is dangerously dependent on imported rice. For reasons obvious to all who have tried growing foodstuffs on tea and rubber estates it is impossible to make good even a small part of the deficiency, and, under normal conditions of storage, not more than three, or at the most four, months consumption can be kept on estates without deterioration. Storage in the Colombo granaries is limited, and concentration of a large and vital proportion of the Island's food supply at one point is dangerous. Such considerations led to investigating the possibility of establishing an "iron ration" on estates, a quantity which would help to tide over a period of interruption of supplies and which would keep indefinitely.

A note on this inquiry and its results may be of interest.

Rice may be damaged or lost by attacks of rats, weevils, microscopic insects, or moulds. Rats can be dealt with in any properly built store, the others make long storage in ordinary conditions impossible. They could, however, be controlled if dry rice could be stored in a dry chamber, or in the presence of a harmless gas which supports no forms of life. The possibility of building a gas-proof dry store was investigated, with a view to flooding it periodically with either a poisonous gas, such as cyanide, or carbon monoxide generated from the exhaust of a car, or with a heavy gas such as CO_2 which would present fewer difficulties and would "stay put" longer. Mr. L. P. Gapp and Mr. G. R. Whitby of the B. C. C. became interested and the latter gentleman offered a solution as to the "store". The British Ceylon Corporation could offer steel "dumpy" drums costing Rs. 13 which would hold 8 bushels. The drums would have a return value of about Rs. 8 if in good order. Room for a number of these could be found in most factories. It was thought that some poison gas, such as cyanide would have to be introduced. Mr. W. R. Thomson of Messrs. Shaw Wallace & Co., kindly worked out the amount of cyanogas required for drums of this size. On this basis some bottles were filled with weevilly rice "doped" with the proportionate amount. All weevils were dead in a few minutes. Another bottle was filled with weevil-infected rice but without other treatment.

Within three days these were dead, having exhausted the oxygen. Subsequent microscopic examination showed no growth of other parasites or fungi.

Thus encouraged, 44 drums were ordered. Each was filled with 8 bushels of rice, previously well sun-dried, and into the bottom of each drum $\frac{1}{4}$ oz. of cyanogas had been placed, tied up in fine cloth with a long string attached so that it could be fished for and removed before returning the drums, and would not directly contaminate the rice. Later tests proved that the cyanogas is unnecessary if the rice has been well dried, the drums fully filled and the screw bungs made airtight with rubber washers. Separate lots of 8 bushels were thinly exposed to the sun on jute hessian for about 2 hours and turned over. While still hot, the rice was put into the drums, with a specially made funnel. The drums had to be rocked and the rice poked with a stick in order to get in the full amount. The bungs were then screwed home and a seal applied to detect theft. The dates of filling were painted on. The labour of drying and filling requires some organization, otherwise much time is wasted. The first 2 were filled on August 20, 1940, and the last 9 were filled on September 27, 1940.

A drum filled on August 31, 1940, was opened for inspection on May 3, 1941, *i. e.*, 9 months later. The rice was found in perfect condition. It had lost about 6 measures through drying, but this was made good by exposing the rice to normal atmospheric conditions for 3 days before issue. One drum was purposely filled with weevil infected rice. When opened the weevils were dead and the rice was undamaged.

Between June 28, 1940, and July 13, *i.e.*, after some 10 to 11 months storage, 13 drums (104 bushels) were opened and the rice issued, also in perfect condition. These drums were re-filled with sun-dried rice but without cyanogas.

		Rs. c.	
Cost of rice per bushel on estate	..	4 76	
Filling, without the cost of steel drums	..	0 7	
		4 83	per bushel.

If the drums were used once only and subsequently sold for Rs. 8 an additional cost of $62\frac{1}{2}$ cents would have to be added, bringing the total cost to Rs. $5 \cdot 45\frac{1}{2}$ per bushel. The present price of rice shows a small profit, but the main thing is that this estate has an "iron ration" of 352 bushels, or enough to keep the labour for two months should supplies be temporarily cut off. Before rice control is enforced it would seem to be a wise measure for the Controller to announce that rice stored by some such permanent means should not be forced into immediate issue after control is introduced. With so large a population dependent on imported food in time of war it seems an elementary precaution to encourage the establishment of widely distributed and permanently stored rice.

DEPARTMENTAL NOTES

COTTON CULTIVATION IN CEYLON*

THE first mention of cotton in Ceylon is to be found in BK LXXII. of the Mahavansa, dated about 1164 A. D. but it is likely that it was used long before that time. As far back as 161 B. C. (BK XXV.) there is mentioned the existence at Anuradhapura of a canopy of " 8000 pieces of cloth of every hue ", and it is feasible to suppose that the cloth was cotton cloth. The cotton would of course be Indian cotton, for it is quite certain that no other kind was available in those early days. Perhaps I should here explain that there are in cultivation very many forms of cotton, and there are almost as many opinions on the way they should be classified. I do not propose to waste either your time or mine in discussing this matter; commercially cottons are divided into long, medium and short stapled according to the length of the fibre which grows from the seed coat, and which forms the cotton of commerce.

Long-stapled cottons have a fibre of $1\frac{1}{2}$ inches length or more, and include Sea Island types, which produce the longest of all fibres (up to $1\frac{3}{4}$ or $1\frac{7}{8}$) and Egyptians, with a fibre length round about $1\frac{1}{2}$ in. Sea Island cotton was formerly grown in the Southern states of N. America, but has now been abandoned there, largely because of the ravages of the boll weevil. It requires a sea-board climate and is now grown almost entirely in the W. Indian islands. It is the most valuable of all the cottons, but is a poor yielder, and the market for this type of cotton is strictly limited. The Egyptian cottons are a hybrid race, being built up from an indigenous brown cotton and a white Sea Island type. They exist in two types, a brown or khaki cotton resembling the original tree cotton of Egypt, which grows well but is unsuitable for dyed fabrics on account of its colour, and a white, which is now being developed to a greater extent than the other. Though not so hardy, it is white and can therefore be dyed, and it is earlier than the brown and is therefore not so subject to the attacks of the boll-worm. Egyptian types are essentially to be grown under irrigation (under which they were evolved) and have done consistently well only under those conditions. The plants are tall and straggling in habit.

* Being the text of a talk given by Dr. J. C. Haigh, Botanist of the Department of Agriculture, to the Committee of the Low-country Products Association, in Colombo, on October 9, 1941.

Medium-stapled cottons have a fibre length of 1–1¼ inches, and form the bulk of the European spinning market. The chief source of supply is the U. S. A., where the American uplands varieties have been developed, although it is likely that the original type came from Asia. The Cambodian cotton that has been grown in Ceylon for many years belongs to this type. It is naturally a perennial, but is treated agriculturally as an annual, chiefly for pest control. It will grow on most soils, but too-heavy types should be avoided in dry tropical areas, as the cracking which occurs in dry weather will injure the numerous side roots ; in temperate climates, this factor is not of importance. Uplands cottons will mature with only 20 inches of rain if it is well distributed ; heavy rain produces excessive growth on light soils and may check growth entirely on heavy soils, by producing a water-logged condition. Too much rain also encourages pests, particularly the boll worm. These cottons are planted in rows about 3 feet apart, on ridges if the rainfall is heavy. They require a growing season of about 3 months, during which the weather should be hot and wet, with rain falling at frequent intervals ; this should be followed by a dry season of about the same length, during which the plant flowers, and matures its bolls. The crop ripens uniformly, so that there are few pickings at harvest time.

Short-stapled cottons have a fibre length from ½–1 inch and are represented in commerce by the Indian types. They are also naturally perennial, and have a short, coarse but strong fibre. Like the upland types, they have a long taproot, but whereas in the Upland cottons the lateral roots run horizontally and are near the surface, those in the Indian cottons go down at a much more acute angle. These types are therefore drought-resistant and will grow in climates with not more than 10 inches of rain per annum. They are planted more closely than the upland types (18 inches instead of 3 feet) or they may be planted at the same spacing and interplanted with grain crops (*e.g.*, Kurakkan). They are the earliest of all the cottons, maturing in 4–4½ months, and producing small bolls, which are picked at frequent intervals.

I have found no record of cotton cultivation in Portuguese times, but the Dutch had a local cotton industry and may have been responsible for the introduction of New World cottons into the East. That industry received a severe set-back when Government imposed a tax on manufactured articles, but it persisted, and may even have flourished in out-of-the-way villages. Various introductions were made in the early days of the British occupation, and a traveller in 1816 reports that "although all kinds of cotton will grow freely in Ceylon, yet none is cultivated because of lack of capital, and all cloth is

imported". This statement cannot be strictly true, because there are records of a very old industry in Batticaloa which produced sheeting, towelling and table wear, and which is likely to have been a relic of Dutch times; nevertheless, there seems to have been no cultivation on a large scale.

It appears from a study of Ceylon agriculture that periodically there arises an impetus towards the cultivation of some particular plant which is ordinarily grown only in small quantity. At intervals throughout the 19th century such an impetus was directed towards cotton cultivation. In 1833 Government distributed seed in large quantities, in 1848 the then director of the Royal Botanic Gardens, George Gardner, strongly recommended cotton cultivation for the North-Central Province and in 1851 his successor, Thwaites, distributed seed of an American variety, and a pamphlet of instructions for its cultivation. In 1853 Dr. Kelaart published useful notes on cultivation, recommending particularly the Sea Island variety, and the matter was warmly taken up by the Kandy Agri-Horticultural Society. This Society obtained from the Manchester Cotton Supply Association no less than 40 casks of Sea Island seed from America and in 1858 this was largely distributed throughout the Island. In 1859 Mr. J. A. Caley published an elaborate report on the present condition of cotton cultivation in Ceylon, with a map showing the districts suitable and the proposed ports for shipment. By this time it had been clearly shown that the moist region of Ceylon possessed too uncertain a climate to allow of regularly-good crops, however well the American kinds might seem to flourish in certain seasons. For many years after that, Peradeniya contrived with some difficulty (since it lies in the moist regions) to keep up a supply of seed of the different kinds, but by 1863 all interest in cotton had completely died out. The factors responsible are said to have been the unsuitability of the weather, the lack of an organized market and the high cost of production, which could not compete against the fall in the world price of cotton and the low cost of imported cotton goods.

For twenty years cotton cultivation was forgotten, but interest was revived again at the time of the coffee crash and in the 80's another wave of enthusiasm was started. Seed was again distributed from Peradeniya through the agency of the Revenue Officers, and some good crops were reported. More detailed records are available from this period of the performance of different types in various parts of the Island, and it is apparent that in spite of past experience, attempts were still being made to grow cotton in those areas which have rain in both monsoons. Indeed, good crops of Sea Island cotton were raised at Gampola and the quality of the lint received favourable reports from England; but it is significant

that the best results were obtained in those years when the N. E. monsoon was considered to have failed. At this time (1888) the Ceylon Spinning and Weaving Co. was established and opened a mill in Colombo, and it was hoped that the provision of a regular market would stimulate cultivation. The hopes were not realized ; by 1891 enthusiasm had died, and for the next 10 years no mention of cotton is to be found in agricultural literature or reports. In 1901, however, it was announced that a railway was to be built to Jaffna, and it was urged that the opening up of the northern part of the Island which was confidently expected to follow the opening of the railway, would provide an excellent opportunity for the establishment of a cotton-growing industry. The idea was encouraged by the newly-founded British Cotton-Growing Association. The chief source of cotton to Europe was at that time the U. S. A., but consumption in that country was increasing faster than production, the attacks of the boll-weevil were spoiling an increasingly-large percentage of the crop and the amount of cotton available for export was becoming less each year. The threatened shortage caused great anxiety to the Lancashire cotton trade, and the new Association set out to establish a cotton-growing industry within the British Empire, and so to become independent of American supplies. Large-scale experiments were started in the Anuradhapura District, at Maha Illuppalama, with Indian cottons for the local market, and Egyptian and American varieties for export to Europe. Those with Indian cottons were soon abandoned ; it is true that cotton of excellent quality was produced and that yields equal to those in the Tinnevelly district of India were obtained, but the value of the crop, including the seed, was only Rs. 15 per acre, which was very much less than the cost of raising it. In fact, the cost was five times the returns, and although cotton grown under these conditions might be acceptable to a cultivator who took no count of the cost of his own labour, it was obviously not a commercial proposition. Attention was therefore concentrated on longer-stapled cottons, which produced excellent crops at first. They did not last ; the weed growth smothered them, the rains spoilt them, and enthusiasm for cotton cultivation was not equal to the strain put upon it. About the same time the mills went into liquidation.

A change in procedure was made in 1909, as a result of the visit of the Director of Agriculture in Nyassaland. He suggested that since the heavy rains of the N. E. monsoon encouraged undue vegetative growth, and the untimely rains of March spoilt the ripening crop, the planting season should be changed, at least where irrigation facilities were available. For the next two years, therefore, cotton at Maha Illuppalama was planted in February, when the N. E. monsoon was over.

It did no better than before; the winds of July whipped off the seed cotton, and the crop was not fully gathered in before it had to be uprooted to prepare the land for the next season. A return was made to the old system, and an attitude of resignation to the difficulties and limitations of cotton cultivation was officially adopted.

This attitude was encouraged if not produced, by a report made by Professor Wyndham Dunstan of the Imperial Institute, who visited the Island in 1910 on behalf of the British Cotton Growing Association. He wasted no words in sympathy and few in encouragement. He considered that no experiments should have been necessary to prove that Indian cottons could not be grown with profit in Ceylon; that attempts to grow Egyptian cotton, which has a long maturing period, were not likely to be successful in any area in which there was not complete control over the water supply, that there was no evidence that Sea Island could be properly established and that in any case a cotton of such superfine quality would require much more careful attention than it would be likely to get; and finally that systematic and properly-conducted (how unkind!) experiments should be made with types of American Uplands, which had hitherto received little attention. The appointment of an expert was recommended, but was not supported by Government, who considered that in the then-flourishing state of the rubber, coconut and tobacco industries, the small profits to be made from cotton cultivation were insufficient to attract capitalists, even were expert advice available.

About this time, the late Sir Marcus Fernando reported the results of trials made in the Kurunegala district of sowing cotton in between rows of coconut trees. Good quality cotton was produced, and yields were sometimes encouraging, but the crop was often ruined by untimely rain. His example was not followed.

The centre of interest now shifts to the Hambantota district of the Southern Province, where experiments were started about 1912, largely as a result of the enthusiasm of Mudaliyar Amarasekera, but little serious attention was given to the crop until 1920, when free seed was distributed and experiment stations were opened. At this time there was a depression in the rubber industry, and many people were looking for other crops to grow. The Mills had been saved by the aid of the BCGA and joined in the search for land on which to grow cotton. Trials were also made in the Northern and other Provinces, and in 1922 seed was distributed sufficient for planting 600 acres. Past encouragements and warnings were alike ignored, and a fresh start was made with a complete range of varieties from short-stapled Indians to long Sea Islands. Yields were good ($5\frac{1}{2}$ cwts. from Sea Islands, 6 cwts. from Uplands, 4 cwts. from Egyptian) and

the department of Agriculture made arrangements to purchase seed cotton for cash from small growers. It also made arrangements to sell such seed cotton to the Spinning and Weaving Mills, at a price to be agreed upon each year. The price was for seed cotton delivered in Colombo; the department collected, graded and forwarded it, and deducted only the cost of transport and travelling expenses; no charge was made for the time of the officers engaged in this work.

In 1923, 1,600 acres of cotton permits were taken out, but the weather interfered with the clearing operations and not more than 400 acres were cultivated. The crop was sold to the mills at Rs. 25 per cwt. of seed cotton, and the cultivator made five times as much money as he could from grain crops. In 1924 the acreage was estimated at 1,500, crops were not so good, but prices were still high. In 1925 Mr. E. R. Hilson, Cotton Specialist to the Government of Madras, visited the cotton areas of Ceylon and reported on their possibilities. He considered that soils were generally suitable, but that dry zone areas could be classified by their rainfall. The Hambantota district was considered good, Embilipitiya, Anuradhapura and Vavuniya fair, Dambulla worthy of trial, Bibile suitable only in dry years. He advocated the introduction of a rotation system, and advised that an American Upland cotton be grown, of the type of Durango and Cambodia. His recommendations were adopted in that only seed of the Cambodia variety was henceforward issued to cultivators, although a number of types continued to be tried on experiment stations. Schemes of rotation were also put into operation. In 1927 world prices broke, and Government, fearing that to pay an economic price to the cultivator would kill a healthy young industry, subsidized the producer to the extent of Rs. 5·50 per cwt; even then he received only Rs. 20·50. The following year a government grant of Rs. 1·70 per cwt. was required, but the price paid to the cultivator had now fallen to Rs. 19·50 per cwt. In 1929 it was Rs. 18·50 and in 1930 it fell further to Rs. 16. In 1931 it was only Rs. 10, and *this* figure was considerably above world average. In was only natural that this steady and depressing fall in price should discourage the cultivator and the crop from the Hambantota District fell from 2,273 cwt. in 1930 to 819 cwt. in 1931, a large proportion of the chena permits not having been sown. The price went up to Rs. 12 in 1932, being still above market average, but the crop fell to 200 cwt., and in 1933 it was down to 126 cwt. That was the nadir; in 1934, the crop had increased to 956 cwt., at the same price, partly as a result of the increased price and partly because of an especially-favourable season which gave yields above the average. In 1935 the crop was 1,500 cwt., in 1936 it was 3,000, and in 1937 4,000 cwt., and the price was still Rs. 12 per cwt. It will

be noticed that the price had been constant for five years and I must now explain how it came to be so. In 1932 an import duty of 5 per cent. *ad valorem* had been put on raw cotton; the following year the mills complained that their business was being ruined, at least in part because of the import duty. The company did in fact go into liquidation shortly afterwards, but an agreement was made between the mortgagors and Government, that in exchange for the removal of the import duty, the mills would undertake to purchase each year up to 10,000 cwt. of seed cotton at a price that was to remain stabilized for an agreed number of years, and would return to the Department, free of charge, such amounts of seed as it needed for issue to cultivators. The price was fixed at Rs. 12 per cwt., and there can be little doubt that the existence of a sure market and a fixed price stimulated cultivation.

Production in 1938 fell off a little and the price paid was only Rs. 11·70 per cwt. because the mills claimed that the cotton was not of that first grade for which they had stipulated to pay Rs. 12. The falling-off in quality was in part due to heavy rain at the time of harvest, but the mills had complained the previous year that the quality was not up to standard and that it had in fact been deteriorating for some time. The cause of such deterioration is not far to seek, since no systematic selection of seed had been practised. It is an established fact that even in a commercially-pure variety of cotton, continuous selection of seed is necessary if the standard of the lint is to be maintained, but it cannot be claimed that the cotton grown in Ceylon was even commercially pure. It is true that since Hilson's recommendation, made in 1925, none but Cambodia seed had been issued to cultivators, that a fresh supply of this seed had been obtained from India in 1929, and that, in recent years at any rate, the seed supplied to villagers had been taken only from the cotton grown at Liyangahatota, where conditions were considered to be particularly suitable for cultivation. Nevertheless, varieties other than Cambodia were grown on departmental stations even after 1925, varieties other than Cambodia had formerly been issued to cultivators, and were bought by the mills, and it would be expecting a miracle to think that no mixing of seed would take place. In these circumstances seed selection was all the more necessary if quality was to be maintained. When I was appointed Botanist in 1931, I suggested a programme of cotton improvement, but the proposal was dropped because the area under the crop was too small to justify the amount of time and labour that selection would require. When, however, the mills complained that quality was deteriorating to such an extent that the cotton could no longer be called first grade, it was obvious that something must be done, and a programme of selection was started

with freshly-imported seed of Cambodia and of two other varieties of similar type that have been evolved, one in S. Africa and one in Uganda, since Hilson recommended the variety most likely to be successful under Ceylon conditions. Other Upland types from Africa have since been added and recently, on the orders of the Hon. Minister for Agriculture and Lands, Sea Island and Egyptian types have been introduced. All these cottons are being grown on an experiment station at Tissamaharama isolated from village areas, where individual plant selections are made each year and are kept free from contamination by being covered with cloth selfing-bags to prevent the access of foreign pollen to the flowers. Samples of lint of these varieties have recently been submitted to the mills for examination, and some of them appear to be very promising; it will however, be several years before a final choice can be made. Cotton requires from 3–5 years in a new enviroment before it is acclimatized, that is before it will give its best performance, and our newest introductions have been grown for one year only. Nevertheless, a move has been made towards producing a better and more uniform lint which will assure the cultivator a steady and reliable return for his labour. It is of interest to record that there is at present no opening at the Colombo mills for the longer-stapled Egyptian and Sea Island types, because of the nature of the spinning machines used there.

We have now surveyed the history of cotton cultivation in Ceylon, and in order to ascertain what it has taught us, I propose to ask, and to attempt to answer, a few questions. First, are conditions in Ceylon suitable for cotton cultivation. Climatically, the wet zone may be ruled out because it does not have the dry period necessary for the ripening of the crop; the dry zone is nowhere ideally suitable (but that may be said of any area in the world except those in which there is no rain) because of the irregular distribution of the rainfall. Sowing time cannot be earlier than October (I am speaking now of dry land areas), which means that flowering comes in January and harvesting in March-April. The rain during the N. E. monsoon is generally too heavy (except of course when the monsoon fails) and produces either a stunted growth (on heavy soils) or a prolific one (which is a waste of energy). It also produces a growth of weeds which often proves to be too much for the cultivator to tackle, perhaps because it has also laid him low with fever. Rain in January causes the shedding of flowers, buds and young bolls by producing a temporary saturation of the subsoil; this could perhaps be cured by deep drainage, but deep drains are not commonly found in chenas. Rain in March-April may spoil the lint in the opened bolls, may cause more shedding, and will certainly interfere with picking. The

only remedy here appears to be to pick quickly when it is fine. Earlier sowing is desirable, so that the plants may be established before the fury of the monsoon descends and drowns the seed or young seedlings, but early sowing is limited by the incidence of rain. Later sowing to bring flowering time in February, the driest month, exposes the seed to the risk of drowning just mentioned.

Rain, then, either in its abundance, its irresponsibility, or its absence, appears to be the chief enemy of the cotton plant—which is a paradox since without it cotton could not be grown at all. Under present conditions of cultivation, other pests are not of great importance ; there are a few insects which have little more than a nuisance value, and rats and elephants sometimes ruin the cultivator's work. Soils generally are suitable, although in the northern part of the Island there are areas of clayey soil which are not to be recommended. The answer to this question then appears to be that conditions in parts of the dry zone are suitable for cotton cultivation.

The next question is : How should it be grown ? Commercial cultivation appears to have been rejected, and perhaps with reason under present conditions. The uncertainty of the rainfall (it is estimated that the odds against a good year are about 3 to 2) the sparseness of labour in areas of suitable climate, leading to high cost of production, and the smallness of the profit because of low market prices, all combine to drive away capitalist enterprise. Figures of cost are unfortunately not available, but I give, for what they are worth, similar figures from one of our experiment stations. In considering them, I would like you to bear in mind (1) that Government experiment stations have the reputation, whether deserved or not, of being more expensive to run than would be a privately-owned property, (2) that the area from which these figures are calculated is small, and that costs are likely to be increased thereby, (3) that, on the other hand, it is possible that the yields are rather higher because of the small area, which would perhaps offset the increase in cost.

Income and Expenditure statement from an area of 3 acres grown under cotton, being part of a rotation area on a dry-zone experiment station.

Year.	Cost per acre. Rs. c.	Return per acre. Rs. c.	Profit or Loss per acre. Rs. c.	Yeld per acre of seed cotton.
1938–39	48 95	26 11	Loss 22 84	3 cwt. 65 lb.
1939–40	58 2	68 73½	Profit 10 71½	6 ,, 57 ,,
1940–41	49 75	77 0	Profit 27 25	6 ,, 38 ,,
Average	52 24	57 28	Profit 5 4	5 ,, 53 ,,

			Rs. c.	
Rates of pay Men	..	..	0 60	per day
Boys	..	..	0 45	,,
Women	..	..	0 30	,,

Analysis of cost of cultivation (average of 3 years).

			Rs. c.
Preparatory cultivation	..	..	4 24
Manures and manuring	..	..	9 10
Seeds and sowing ..	..	..	3 80
After-cultivation ..	..	..	13 51
Watering (one season only)	..	..	0 15
Harvesting and cleaning	..	..	19 98
Pest control ..	..	..	·1 45
			52 23

In view of these figures, it is for those responsible for agricultural enterprise to decide whether, in view of the limitations that have been outlined and the returns to be expected, they will invest their money in cotton cultivation on a large scale. There remains peasant agriculture. Cotton is now grown entirely in chenas, and all authorities are agreed that, if cotton cultivation is to be a success, it must take its place in a scheme of rotation. The chena cultivator has neither the money to buy implements or fertilizers, nor the interest in the land to use those things if he had them. The land therefore remains unstumped (which reduces the stand of plants and therefore the yield) and unweeded (which reduces the yield still further). The average yield on chenas is not more than 2 cwt. seed cotton per acre ; on experiment stations, under a system of rotation, it is considerably higher. Experiments on stations have shown that the limiting factor in cotton cultivation is weed growth, and that a luxuriant crop of weeds will mask any manurial or spacing effects. For twenty years the officers of the department have endeavoured, by precept and by practice, to persuade the peasantry to adopt a form of rotation, and have failed. This failure is perhaps natural—the cultivator will not till what he does not own, and the tendency in recent years has been to reduce the size of chena permits rather than to increase them. Further, it is not yet proved that it is practicable for the peasant cultivator to adopt a system of rotation ; an experiment to test this point is now being conducted at Kurandankulam, but results are not yet available. Rotation programmes have been worked out for most areas of the Island and are available when required.

The answer to the second question is then that cotton should be grown as a rotation crop in village settlements. Until, however, the chena cultivator is weaned from his present

practice, and not only encouraged, but also helped, to become a mixed farmer, cotton will continue to be grown in chenas, with all the disadvantages attached to that form of cultivation.

The third question is what kind should be grown ? During the past century, every conceivable type of cotton has been tried, and it is significant that, whilst much prominence has been given to the excellent crops obtained from Sea Island and Egyptian types, those types have failed to persist, whereas the more ordinary Upland type has always been grown and is still being grown to-day. Desirable as it may be to wish to grow Superfine cottons, it is commercial commonsense to grow that type which produces the best gross return, and experience in Ceylon indicates that an Upland type answers that description. Moreover, we have a market in Colombo for our cotton that can take only two types—short-stapled Indian and medium-stapled American Upland, and of the two, there is no doubt that Upland is the more profitable. So long, therefore, as cotton is grown under dry land conditions and is sold in the local market, the type to be grown is a medium-stapled American Upland. Of the 17 varieties now being tried at Tissamaharama, 12 are of this type. On the question of supplying the local market against developing an export trade, there can be little argument. With ruling market prices, we could not hope to compete in world trade. In 1938 my department recommended that all Government requirements of cloth should be bought from the Spinning and Weaving Mills ; the proposal was turned down because it was shown that the material already supplied by the Mills, which amounted to about half of that used by Government, was inferior in quality to and higher in cost than that supplied by the Crown Agents. Nor are we likely to be forced into the export market by the overproduction of local requirements. Under the terms of the present contract, the mills will take up to 10,000 cwt. per annum, but that is only a fraction of their total requirements ; our peak year to date has been 4,000, and it has been estimated that under present conditions of cultivation we are not likely to exceed double that amount, *i.e.* 8,000 cwt. Our present output occupies the mills for one week per year ! In addition to seed cotton required by the mills there are the possibilities of a hand-loom industry to be exhausted before export has to be considered.

The next question to be asked is how should it be disposed of ? The question has already been answered above, but there are differences of opinion on the method to be used. Under present conditions, seed cotton is bought in the villages and transported to Colombo ; it is there ginned, and the seed required for the next sowing is transported back again. The cost of transport is considerable (it costs more to transport seed cotton from Hambantota to Colombo than it would from

Bombay) and is borne by the cultivator, so that he loses perhaps Rs. 1·50 to 2 out of the Rs. 12 paid by the mills. It is true that he gets more than he gives, for not only is the organization for the purchase of seed cotton arranged for him, but the time of the buying staff is charged to Government account, so that the disposal of the crop is done for him more cheaply than he could do it himself. Nevertheless, suggestions have been made to save the cost of transport to the cultivator by establishing a ginnery in the Hambantota district. The suggestion was first made in 1934 by Mudaliyar Amarasekera, and again in 1938 by Mr. D. M. Rajapakse, Member of the State Council; it was turned down on both occasions, for what appear to be good reasons. It was argued that a minimum consumption of 4,000 cwt. per annum would alone justify a ginnery, which even then would work for only one month in the year ; that although the Hambantota district was the largest cotton producing area, yet cotton was being grown, and in increasing quantities, in other parts of the Island and that either seed cotton from those areas must continue to be sent to Colombo or other ginneries must be established, and that on these grounds the establishment of a ginnery in the Hambantota district was both impracticable and uneconomical.

I have dealt up to now with future development under conditions of cultivation such as now obtain, but I must, in conclusion, mention that irrigation schemes in the dry zone are now beginning to function, and will offer another possible field for cotton cultivation. It should be possible under conditions of controlled water supply and drainage to produce bigger yields than are produced in chenas ; it may be possible to grow longer-stapled cottons for an export market, perhaps by reviving Mc Call's method of sowing in February and cultivating throughout the dry weather. Whatever happens, the possibilities of cotton as a rotation crop under dry zone conditions will continue to receive the attention of the Department of Agriculture.

THE ALKALI SOIL PROBLEM AND RECLAMATION METHODS IN INDIA AND CEYLON*

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THE methods adopted for the reclamation of alkali soils in India may be grouped under the following three heads :—

(*a*) *Mechanical*, under which is included (i.) drainage, (ii.) leaching with water.

(*b*) *Agronomic.*—These include—

(i.) the growing of suitable crops in suitable rotations,
(ii.) the cultivation of salt-resistant varieties of such crops,
(iii.) green manuring,
(iv.) the application of farmyard manure, compost and other bulky organic residues.

(*c*) *Chemical.*—Of the chemicals used for correcting soil alkalinity, one type, *viz.*, sulphate of ammonia, molasses and sugar cane press mud is utilized, at any rate occasionally, as fertilizers for crops. The other type *viz.*, gypsum, sulphur, alum and iron sulphate, is rarely, if ever, used for this purpose.

In but few instances is the adoption of one of these methods alone sufficient to reclaim an area satisfactorily. In practice, a combination of the mechanical and agronomic methods has been found most effective and economic in India. Owing to the high cost of chemicals, particularly of the second type referred to, they are used for reclamation only when land values are so high or land pressure so great that its reclamation becomes a necessity.

GENERAL POSITION OF THE ALKALI SOIL PROBLEM IN INDIA

Before these methods are discussed in greater detail, it would be useful to indicate briefly the general position in regard to alkali soils in India. Alkali lands in India are known under various names in the different Provinces, *viz.*, *kallar* in the Sind and Bombay Presidency, *thur*, *rakkar* and *bari* in the Punjab, *usar* and *reh* in the United Provinces and Bihar.

* Extract from a report by the author on a tour in India to study the problem of alkali soils.

The alkali problem is most serious in the irrigated areas of the Punjab, the Sind and, to a lesser degree, the Bombay Presidency. It is also serious in the United Provinces, where however, irrigation is not the prime cause of the trouble, at any rate in the greater part of the alkali land in the Province. In Bengal the alkalinity is of the saline type and occurs on soils subjected to inundations with brackish water through tidal influence, as in the Sundarbans in the Gangetic delta. The problem is not considered serious in Bihar and Mysore, at present, though alkali areas occur in various parts of these Provinces. In Madras Presidency, however, the problem causes much concern particularly on certain types of soil and in certain irrigated areas. The alkali salts present in the soils of the Bombay Presidency, Punjab and Sind are mainly of the "white alkali" type. They consist mainly of the chlorides and sulphates of sodium and, in lesser proportions, of magnesium and calcium. In the United Provinces and parts of the Madras Presidency and Mysore, the salts present are mainly the carbonates and bicarbonates of sodium. Investigations carried out have shown the following approximate limits of tolerance of vegetation to different alkali salts in the soil :—

Sodium carbonate	: 0·1 to 0·5 per cent.
Sodium chloride	: 0·2 to 0·3 ,, ,,
Sodium sulphate	: 0·4 to 0·6 ,, ,,

It has been found that, in general, a salt content of 0·2 per cent. in the soil within the root range of most crops will depress yields, while if the salt content is about 0·5 per cent. most crops will fail. In the Punjab rice fails in soils with a salt content above 0·36 per cent. or of a markedly alkaline reaction (pH above 9·5). But crops such as *dhaincha* (*Sesbania aculeata* or *aegytiaca*), lucerne, berseem (*Trifolium alexandrinum*) and certain varieties of sugar cane, rice and sorghum are found to withstand higher salt concentrations and degrees of soil alkalinity than those indicated, provided they are grown under copious irrigation.

THE SCIENTIFIC INVESTIGATION OF THE ALKALI PROBLEM

The investigation of problems connected with the practical reclamation of alkali soils is, in many of the Provinces, mainly undertaken by the Irrigation Research Divisions of these Provinces, particularly in respect of the mechanical methods of reclamation referred to above. The Agricultural Departments are generally responsible for the agronomic and chemical methods of control and reclamation of these soils. But in all the Provinces, the greatest importance is attached to research, both in laboratory and field, for the solution of the many problems connected with this question, and special organizations,

research centres and reclamation farms have been established for the purpose. Of these latter, mention need only be made of the Punjab Irrigation Research Institute with its full complement of research divisions including those for Soil Chemistry, Soil Physics, and Land Reclamation, the Punjab Drainage Division of the P. W. D., the Irrigation Research Divisions of the Bombay Presidency and of the Sind with their corresponding soil research departments, the alkali reclamation centres of Baramati in the Deccan canal area, Dokri in the Sind, Chakanwali in the Punjab, Siriguppa in the Madras Presidency, Babur farm in Mysore, and Unao in the U. P., to many of which research officers are attached.

MECHANICAL METHODS

(i.) *Drainage.*—That adequate soil drainage is most essential in irrigated areas so as (*a*) to prevent a rise in the sub-soil water level and, in consequence, the development of alkali salts in the soil, (*b*) to rectify damage caused by alkali in such soils, is now recognized by all authorities in India and elsewhere. The following quotation from J. Thorpe's *Geography of the Soils of China* is worth noting in this connexion : "In establishing new irrigation projects in a semi-arid region the matter to be taken into consideration is that of drainage, no matter how well the soil is drained under the existing natural conditions. *What we have to see is what steps are taken to drain effectively the area after it is subjected to more intensive irrigation.*" It will thus be clear that no irrigation system can be considered perfect without an efficient system of drains capable of carrying away the excess water and of maintaining the sub-soil water levels at depths suitable for a crop to be grown, and sufficient to prevent a rise of salts to the surface by capillarity if these are present in the sub-soil water or in the soil crust. In the Punjab a minimum sub-soil water depth of 10 ft. is considered necessary if the latter phenomenon is to be prevented, while in the Deccan a depth of 4 ft. generally suffices. If the sub-soil water does not contain an excess of salts, the following water table depths are considered in India to be the minimum for the successful cultivation of crops :—cotton—between 5 and 6 ft. ; sugar cane—between 2 and 3 ft. ; fodder crops—4 ft., and 7 to 8 ft. in the case of lucerne ; rice—not less than $1\frac{1}{2}$ ft. at the time of sowing or transplanting.

Drainage of irrigated areas on a comprehensive scale is undertaken in many of the Provinces of India, particularly in the Punjab and Bombay Presidency. In the Sind expensive drainage works have not been constructed. Where the water-table is too high, mechanical pumping is resorted to. In many of the Provinces, as in the Sind and Bombay Presidency, the rise in sub-soil water level in irrigated areas is prevented by

restricting the cultivation of crops such as rice and/or sugar cane, which require large amounts of irrigation water, to certain areas only. In the Punjab the restriction of rice cultivation is automatically effected, since only 25 per cent. of the cultivable commanded area is allowed irrigation during the *khariff* or hot weather season, when alone rice can be grown. In the Deccan canal areas, Bombay Presidency, sub-soil drainage is carried out on thoroughly sound, scientific lines, by a technique developed as a result of years of research and experience. The methods adopted here can, with suitable modification, be adopted in countries, such as Ceylon, where the soils are derived from igneous and metamorphic rocks *in situ*. In the Punjab, surface, seepage and surface *cum* seepage drainage are all adopted, as well as pumping by mechanical means. Surface and tube well drainage is the practice in the U. P.

(ii.) *Leaching* or the application of heavy doses of water to wash down the salts into the sub-soil or permeable sub-stratum is the most obvious step in the reclamation of an alkali soil. The leaching has to be continuous for a period, if it is to be effective. The construction of bunds around the area to be leached is necessary and so also of drains to carry away the drainage water. The land has to be carefully levelled before it is flooded. In the case of the "white alkali" soils which predominate in the Sind and the Punjab, and the saline soils of Bengal, leaching alone effects a marked reduction in the salt content of these soils. But in alkaline soils, owing to their low water permeability, leaching alone is not sufficient. The use of chemicals to promote water percolation is necessary. The quantity of water required for effectively leaching a white alkali soil varies, but does not exceed 6 acre-ft. per acre in most Provinces. Rainfall, however, is utilized in many places where irrigation water is not available.

In regard to the quality of the irrigation water it has been found in India that all waters with a salt content of less than 50 parts per 100,000 are quite suitable for irrigation. Waters containing less than 50 p.p. 100,000 of soluble salts but having a pH value of about 9 may be dangerous. Waters with soluble salts between 60 and 120 p.p. 100,000 may be satisfactory if the porportion of calcium salts in them are high. If the soluble salt content is greater than 120 p.p. 100,000, the water is not satisfactory for irrigation purposes unless it has a low pH (about 8·0), when further investigation in regard to its composition becomes necessary, or is used on calcareous soils containing over 6 per cent. calcium carbonate. The quality of the sub-soil water is a useful index of the likelihood of alkali development in a soil under conditions of high water-table. In the Sind a sub-soil water with a salt content of less than 120 p.p. 100,000 is considered safe in this respect, one containing

120—1,000 p.p. 100,000, dangerous, one with 1,000—3,000 p.p. 100,000 bad, while one with a salt content greater than 3,000 p.p. 100,000 is considered very bad.

AGRONOMIC METHODS

The growing of suitable crops in suitable rotations is one of the chief methods adopted in India for reclaiming alkali soils. These crops are, however, grown only after the land has been partially reclaimed by drainage and leaching. Rice is the chief crop used for the purpose on such lands in the Punjab, Bengal, Madras Presidency, U. P., Mysore, and sugar cane in the Deccan, Mysore and Madras. Both these crops require large quantities of water and the concentrations of salt in the root zone are thus reduced appreciably. Further, the carbonic acid formed in large quantities in irrigated rice soils aids in the removal of sodium from sodiumized alkali soils. When grown as a reclamation crop, rice is always transplanted. The varieties of rice and sugar cane cultivated are of the salt-resisting type. There are numerous varieties of salt-resisting rices, *e.g. Sathra* 278 and *Jhona* 349 in the Punjab, *Patnai* 23 and *Patnai* 298 in Bengal, Co 2 *Samba* in Madras Presidency, *Torh* in the Sind and T17 and T23 in the U. P. At the Sabour Rice Research Station in Bihar, it has been established that it is possible to grow paddy in saline soils, if the seed is pre-treated with minute solutions of common salt. Of the salt-resisting sugar cane varieties, Co290, Co419, and POJ2878 may be mentioned. Among the leguminous crops which, owing to their ability to withstand relatively large amounts of salt in the soil and high degrees of alkalinity, are extensively used as reclamation crops, are berseem clover (*Trifolium alexandrinum*), an excellent winter fodder, *dhaincha* (*Sesbania aculeata* or *aegyptiaca*), a summer green manure crop, and lucerne. Sunnhemp is grown largely in the Bombay and Madras Presidencies, the U. P. and Mysore. These leguminous crops are generally grown prior to rice for green manuring purposes, but in the Punjab the reverse practice is followed. In Mysore *hongey* (*Pongamia glabra*) leaf material is popular as a green manure on both alkali and normal soils. On the more alkaline type of soils in the Sind, certain tannin-containing materials, *e.g.*, *babul* (*Acacia arabica*) bark and *khabba* (*Salvadora* spp) leaves, have been found very beneficial for improving soil drainage and reducing alkalinity. Following on rice or sugar cane and a green manure crop, *rabi* (winter) or *khariff* (dry season) crops such as cotton, sorghum, *cambu*, *ragi* (kurakkan), wheat and pulses are grown in rotation, if the land is considered fit for these crops. Sorghum, *cambu* and kurakkan are reputed to be tolerant to small quantities of salt in the soil. But whatever rotation is adopted, in no circumstances is the land, once it has been

brought into cultivation allowed to lie fallow. On the more refractory types of alkali soils such as are widespread in the United Provinces, and common in certain parts of the Punjab (the so-called *rakkar* or *bari* soils), the rice *cum* green manure treatment is repeated successively until the land is ready for other crops. In the U. P. such soils are bunded and rainwater or irrigation water impounded. The plots are then left fallow in order to promote the development of natural pasture grasses. No grazing is permitted for a year or two. The land is subsequently ploughed up, leached, green manured and cropped with rice. In many instances, however, alkali soils of the markedly alkaline type can be successfully reclaimed only by supplementing these mechanical and agronomic measures with chemical correctives. The cost of reclamation is then frequently uneconomic.

One of the most feasible of the agronomic methods of reclaiming mild alkali soils is the application of heavy dressings of farmyard manure (10 to 20 tons per acre), bulky organic manures and residues such as compost, town sweepings, root stubble, &c. It has been found at Padegaon Sugarcane Research Station in the Deccan, Bombay, that farmyard manure is much more effective for this purpose if it is used with other soil ameliorants such as sulphur. In the U. P. the burial of root stubble of sorghum and sugar cane has proved beneficial in reclaiming mild *usar* (alkali) soils. The intensive cultivation of all crops grown at any stage of the reclamation of an area, and even subsequent to it, is very essential if the area is to be successfully reclaimed and so maintained.

CHEMICAL METHODS OF SOIL RECLAMATION

The chemical correctives or soil ameliorants which are occasionally used in India as a supplement to the mechanical and agronomic methods outlined above for the reclamation of typical alkaline soils with high pH values, are gypsum (calcium sulphate), sulphate of ammonia alone or in combination with other soil amendments, molasses, sugar cane press mud, and sulphur.

The use of the last-mentioned material is hardly likely to be an economical proposition, except where land values are high, its cost being about Rs. 150 per ton and the quantity required for reclamation, from 1 to 2 tons per acre. It has, however, been very successfully used for reclaiming a typically alkaline soil in the Trichinopoly district of the Madras Presidency, and is recommended for application at the rate of $\frac{1}{2}$ to 1 ton per acre along with farmyard manure at the rate 5 tons per acre, for the speedy reclamation of typically-alkaline *chopan* soils of the Deccan, Bombay Presidency.

Molasses is a by-product of the sugar cane industry. It contains between 60 to 70 per cent. carbohydrates, 4 to 5 per cent. potash, 2 per cent. lime, 0·5 per cent. nitrogen, 0·5 per cent. iron and aluminium oxides and 0·5 per cent. sulphuric acid. Its value as a soil ameliorant for alkali soils was first demonstrated by Professor N. R. Dhar of Allahabad. He showed that markedly alkaline soils could be successfully reclaimed for growing rice by using from 5 to 10 tons of the material per acre, but quantities as low as 1 or 2 tons have also proved satisfactory on certain soils. The high cost of the material and difficulty of transporting and applying it, militate, however, against its extensive usage for the purpose. Good results from its application have also been secured on alkaline soils in Mysore and at the Government Farm Unao, U. P., rice being the crop grown in every instance. In Bihar and the Deccan equally successful results have been obtained, the crops grown in these cases being sugar cane. The effect of the molasses is : (1) to neutralize the soil alkalinity through the acids present in and produced as a result of its decomposition, and (2) to convert the sodium carbonate into the soluble bicarbonate through the carbonic acid gas liberated in the decomposition process. The lime present in it converts the sodium clay into a calcium clay with consequent improvement in the physical properties of the soil.

Much more promising from the reclamation standpoint is press mud, a waste product of cane sugar factories. This material contains, on the average, 50 to 55 per cent. organic matter, 0·8 to 1 per cent. nitrogen, 2·5 to 3 per cent. phosphoric acid, 0·8 to 1·0 per cent. potash and 6 to 8 per cent. lime. Used either alone or with molasses on markedly alkaline soils at rates from 2 to 5 tons per acre, it has proved very successful in Mysore, the U. P., Bihar and Bombay Presidency.

Gypsum has been found very satisfactory as a reclamant for markedly alkaline soils and has been used to some extent for the reclamation of such soils at Trichinopoly in the Madras Presidency, Kalashahkaku Farm and other centres in the Punjab, Baramati, Padegaon, &c., in the Deccan. The amounts used average 3 tons per acre, and the cost of the treatment varies from Rs. 50 to Rs. 125 per acre. Gypsum converts the sodium carbonate of these alkali soils to the easily leached sodium sulphate.

Sulphate of ammonia is useful for ameliorating the soil conditions of the milder types of alkaline soils. As such soils are very deficient in nitrogen, this and other nitrogenous alkali soil amendments are, in addition, of direct advantage to the crops grown on the reclaimed lands.

Trials with lime and ground limestone on alkaline soils have been made, but for satisfactory results the addition of green or other bulky organic manure was found necessary.

The less well-known chemicals used in other countries for alkali land reclamation, *viz.*, alum, sulphate of iron and calcium chloride have not been used on any scale in India, except in a few isolated trials. Their cost renders their usage prohibitive.

Owing to their generally high cost and the difficulty of procuring or applying them, no extensive use of most of these materials for alkali soil reclamation in India is anticipated. Gypsum, press mud, and molasses, where it is easily available and cannot otherwise be disposed of, offer the greatest possibilities in this direction.

THE ALKALI PROBLEM IN IRRIGATED AREAS IN CEYLON AND ITS CONTROL, WITH PARTICULAR REFERENCE TO MINNERIYA

The Alkali Soil Problem in Ceylon

The alkali soil problem, as distinguished from the saline soil problem caused by salt water inundation, is by no means a serious one at the present time in Ceylon ; but if the necessary measures to prevent its development in the irrigated areas of the dry zone of the Island are not taken in time, there will undoubtedly be cause for apprehension in the future on this score. While comparatively small extents of alkali soils do occur in practically all the irrigated tracts of the dry zone, whether under large irrigation schemes such as the Kalawewa, Walawe, Kirindi-oya and Minneriya Schemes or under smaller tanks, the total area of such lands is not probably, at present, very great. Only a detailed salt survey will reveal the extent of these areas, but there is good reason for believing that soil alkalinity of various degrees of intensity is responsible, to some extent at any rate, for the low yields of paddy in some of these irrigated tracts. The salts present in most irrigated areas in Ceylon are those of white alkali, *viz.*, the chlorides and sulphates of sodium and magnesium.

The development of alkali salts in low-lying irrigated areas in the dry zone of the Island is mainly due to defective or poor soil drainage. Only seldom is the trouble due to an excess of soluble salts in the irrigation water, as is occasionally the case with the water of certain village tanks and rivers contaminated with salt water, or to the presence of soluble salts in the virgin soil in quantities likely to be injurious to crops, as is of such frequent occurrence in India. But the predisposing causes to alkali formation do exist in certain irrigable tracts of the dry zone. These are : (i.) a fairly prolonged period of dry weather during which evaporation and capillary action are at an optimum, alternating with a period of heavy rainfall ; (ii.) a low-lying situation rendering natural drainage defective or impossible ; (iii.) the presence of an impervious sub-soil, hard pan, or rock at a comparatively shallow depth ; (iv.) comparatively large percentages of soluble salts in the sub-soil water.

It is well known that the water in many parts of the dry zone is brackish owing to dissolved salts derived from the weathering of gneissic and igneous rocks which underlie the greater part of the Island. In poorly-drained areas in the dry zone, the sub-soil water level rises as a result of irrigation and the salts contained in the water are brought to the soil surface during subsequent periods of drought. In the course of time an accumulation of salts occurs in the soil in quantities deleterious both to dry land crops and to paddy. The latter is, however, able to withstand a higher concentration of these salts in the soil for reasons already indicated. If the salts are allowed to remain for a sufficiently long period, the soil deteriorates and a typical alkaline soil is formed. Apart from being directly injurious to crops, such a soil has the disadvantages of poor tilth and of being impervious to water. Soil drainage, therefore, becomes a very difficult proposition, and the application of chemical correctives and bulky organic manures becomes imperative if the soil condition is to be ameliorated.

METHODS FOR PREVENTING ALKALI SOIL DEVELOPMENT IN IRRIGATED AREAS LOCALLY

It will thus be realized that of all the measures necessary to prevent the development of alkali salts in irrigated soils or to rectify such alkalinity where it has occurred, effective drainage is the most important. Any measures taken in this connection should be comprehensive, *i.e.*, should relate to the scheme as a whole and not be confined to particular sections only. Drainage must be undertaken after due consideration of a number of factors, *viz.*, the nature and depth of the soil, type of sub-soil, the topography and geology of the area, &c. To be effective, drains must be designed to carry away excess water and to maintain the sub-soil water level at depths suitable for the crops to be grown, and must therefore be cut well into the permeable sub-stratum. Sub-soil surveys such as are carried out in the Bombay Presidency by field officers of the Irrigation Research Division with the co-operation and general advice of the soil scientists, should be a preliminary to the construction of any extensive drainage scheme in the irrigated areas of Ceylon. The drainage technique adopted in this Province would appear to be one which might well, with modification, be followed in Ceylon. The type of drains, their dimensions, distances apart, &c., should be carefully pre-determined, if unnecessary expenditure is to be avoided. The contouring and careful levelling of paddy fields should always be practised, as drainage is thereby promoted.

Certain soils are, however, difficult to drain satisfactorily owing to their intrinsic nature. Such soils are those with a high degree of alkalization, *i.e.*, the percentage of replaceable

sodium and potassium to total base exchange capacity, or with a relatively high propotion of replaceable magnesium in the clay complex, or those containing high percentages of clay of the montmorillonite type. In addition to increasing the frequency of drains, one or more of the following agricultural treatments become, therefore, necessary on these soils :— liming, green manuring, bulky organic manuring, the application of physiologically-acid fertilizers such as sulphate of ammonia, and intensive cultivation.

If the soil is well drained and well cultivated, and if green and bulky organic manuring and occasional liming are adopted in the newly-opened irrigated tracts of our dry zone, there should be little, if any, danger of alkali salts developing in them. The green manures recommended for local conditions are sunnhemp (*Crotalaria juncea*), *Crotalaria striata*, *pila* (*Tephrosia purpurea*) which has the advantage of re-establishing itself once it has been introduced into an area, and *Sesbania aculeata* or *aegyptiaca* (*dhaincha*). Much more use, as in India, should be made of the last mentioned crop, which is able to grow under fairly moist soil conditions such as obtain in many paddy fields and can stand alkaline conditions as well. *Pillipesara* (*Phaseolus trilobus*) which is grown largely in certain parts of S. India and *shevri* (*Serbabia aegyptiaca*) which is grown in the Bombay Presidency, should also be experimented with.

METHODS OF RECLAMATION OF ALKALI SOILS LOCALLY

If the soil of any area has developed alkali, the measures that may be recommended for adoption in Ceylon are as follows :—

(1) Effective drainage. Open drains will generally be preferable under most local conditions, but pipe or mole drains may be necessary in certain circumstances.

(2) Continuous leaching with water for varying periods up to 8 weeks, depending on the efficiency of the drainage, in order to wash down the salts to the sub-soil. The area will have to be divided into small blocks, each bunded and drained all round, before the leaching process is begun. The careful levelling of the land is also very necessary. The blocks should be laid out on the contour.

(3) Leaching should be followed by the cultivation of a green manure crop in the area. One of the crops mentioned should be selected. This crop should be turned in later. In the alternative, heavy dressings of green manure, farmyard manure, compost or other bulky organic manure should be given. The application of 1 to 2 cwt. per acre of sulphate of ammonia will also be advantageous.

(4) A crop of *transplanted*, salt-resistant paddy should then be grown. Trials with salt-resistant varieties of paddy have already been started by the Paddy Officer. Some of these

varieties are being tried out in a block of alkali soil at Minneriya, now under reclamation by the methods herein outlined. Investigation may show that the Sabour (Bihar) method of pretreating paddy seed of the varieties grown normally in an area with very dilute salt solutions may render these varieties suitable for cultivation on alkali soils within the area.

(5) An application of ground limestone or preferably gypsum (calcium sulphate) at rates up to 2 tons per acre, should be given at the start of the reclamation process to soils which are either markedly alkaline (with high pH values) or which have a relatively low calcium/total base ratio. Whether this is so or not can only be determined by analysis. Burnt lime can be substituted for calcium sulphate or carbonate where the latter are not available, but is not so efficacious.

(6) Following on paddy, a second green manure crop should be taken, to be succeeded again by paddy. From the standpoint of soil reclamation, it is very beneficial to take *two* crops of paddy each year until the area is fully reclaimed. The land should not be allowed to lie fallow for any length of time. Failing two crops of paddy, one of paddy and one of a green manure or other crop should be taken.

(7) Once the land has been successfully reclaimed for rice, it could be utilized for growing other crops in rotation, such as sugar cane (salt-resistant varieties of which, *e.g.*, Co290, Co413, Co419, Co421, POJ2878 should be grown in the first instance), sorghum, kurakkan, *cambu* and at a later stage, cotton, other soil conditions being satisfactory.

If and when a sugar cane industry develops in the Island, molasses, press mud or a mixture of the two could be usefully employed for reclaiming alkali soils of the more refractory type. For the present, their utilization for this purpose is entirely ruled out, and so also is the use of sulphur owing to its extremely high cost.

MINNERIYA ALKALI SOIL RECLAMATION TRIALS

It will be of interest to mention in this connexion that trials with the reclamation of a 5-acre block of land of about 25 acres extent at Minneriya, which had developed alkali salts as a result of a high sub-soil water level and bad drainage (due to a low topographical situation), on the lines indicated above, have after but one season of experiment, given most encouraging results. The drainage of the whole area by the Irrigation Department had preceded these trials. The necessity for adequate leaching, careful levelling and thorough cultivation, and the great value of green manuring and liming these soils have already been clearly established. The usual variety of paddy grown in the Minneriya Scheme during the *yala* season,

viz., *pachchaiperumal*, was found satisfactory. Certain salt-resisting varieties have also been tried out by the Paddy Officer, but some of these have proved unsuitable for the particular conditions.

THE RECLAMATION OF SALINE SOILS IN CEYLON

Typically saline soils in Ceylon such as occur in areas subjected to periodical flooding with salt or brackish water, *e.g.*, the Mutturajawela and other low-lying tracts of the Western Province, can be reclaimed by methods similar to those adopted for the reclamation of the alluvial saline soils of the Gangetic delta, *viz.*, the Sundarbans in Bengal. Here the river water which is saline owing to tidal action overflows into the surrounding land during times of flood. The method suggested for reclamation of such lands locally is as follows :—

(1) Exclusion of salt or brackish water by bunds.
(2) Leaching of the salts with rain or irrigation water, if available.
(3) Removal of excess water through sluice gates or by mechanical pumping, if necessary.
(4) Drainage through surface drains of adequate depth.
(5) The growth of a transplanted, salt-resisting variety of rice. If the land was previously under jungle, a broadcast crop may have to be taken for a year or two until the stumps of trees can be removed. The Sabour (Bihar) method of pre-treating paddy seed with minute solutions of salt prior to planting has possibilities for these soils.
(6) The application of lime in sufficient quantity, if the soil is strongly acid, as are the Mutturajawela soils, in order to correct this defect and to effect rapid decomposition of the peaty material.
(7) If found necessary after trial, the application, as in Bengal, of copper sulphate as a soil amendment at a rate up to 100 lb. per acre, in order to precipitate the excess of ferrous (iron) salts in the soil and to remove the toxic organic matter decomposition products.

THE NEED FOR RESEARCH ON THE PROBLEM AND OF DETAILED SOIL SURVEYS

Before the reclamation of any alkali soil on a large scale is attempted, it is most essential that field trials on a fair scale should first be carried out to determine the mechanical, agronomic and chemical measures necessary for the economic reclamation of the type of soil. Simultaneously with these field trials, chemical and other determinations should be undertaken to study by means of observation tubes the change in sub-soil water levels as a result of cultivation and irrigation,

the variation in the salt contents of different horizons of the soil down to water-table, &c. This is the procedure universally followed in the different Provinces of India and is strongly recommended for adoption in Ceylon.

In India, and for that matter in S. Africa, Australia, Egypt and other countries where large irrigation schemes are in existence it is now the universal practice for *detailed*, comprehensive soil surveys to be made of the areas to be developed under any proposed irrigation project. In the Madras Presidency, for example, a sum of approximately Rs. 45,000 was spent in conducting a soil survey of the Tungabhadra Project covering an extent of about one million acres. In the Punjab these and more detailed soil surveys are carried out, the cost of the latter being Re. 1·25 per acre. In Australia and S. Africa these surveys are even of a more detailed character, and a soil survey of an extent of 10 to 15,000 acres will occupy the full time of at least two soil chemists, and a staff of field assistants and labourers for periods varying from six months upwards. Of the need for detailed soil surveys of this nature in Ceylon, I am definitely convinced, after having personally conducted over 40 preliminary reconnaissance soil surveys of areas under proposed irrigation and colonization schemes.

I am definitely of opinion that we in Ceylon cannot afford to neglect this important aspect of agricultural colonization in the dry zone under irrigation. I cannot conclude this section better than by quoting from the United States Department of Agriculture Year Book for 1938, *Soils and Men*, a passage which may safely be taken as the official American outlook on this subject.

"The plans for an irrigation enterprise should include the survey of the soils and classification of the lands as well as investigation of the available irrigation water and the means of conserving it and conveying it to the land. Furthermore, experience has shown that, after irrigation has become established, re-examinations of the soil should be made from time to time to determine the trend of changes that may occur in the root zone in consequence of inadequate sub-soil drainage or the accumulation of soluble salts . . . . . Meanwhile the work of constructing and operating irrigation projects goes on. Avoidable mistakes are made and there are many failures. Questions are raised as to the permanence of irrigation agriculture because of uncertainties as to the causes of the trouble . . . . . These are the reasons for emphasizing the need of careful, detailed soil surveys and land classification prior to the development of projects."

HISTORY OF THE DEPARTMENT OF AGRICULTURE, CEYLON

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II.—PARALLEL DEVELOPMENTS

A.—THE BOTANIC GARDENS, 1822—

B.—THE GOVERNMENT AGENT ADMINISTRATION, 1833—

C.—THE AGRICULTURAL SOCIETY, 1904.

A.—THE BOTANIC GARDENS

"THE Gardens" became an Institution and a Department long before the Department of Agriculture was established. In 1909 Mr. Herbert White of the Civil Service was able to say in his *Ceylon Manual* :—

"The Department of the Public Service of Ceylon known as the Royal Botanic Gardens includes at the present time a much wider range of activity than its title would indicate to residents in Europe ; it is rather a Department of Botany and Agriculture than a Botanic Garden in the ordinary sense, though it includes a number of Botanic Gardens."

Botanical research

Ceylon flora had been brought to the notice of European botanists comparatively early in the history of botany. A happy association with a future Professor of Botany at Leyden brought Ceylon prominently to the notice of European Botanists. This was PAUL HERMANN, who when Chief Medical Officer in the Dutch East India Company's service in Ceylon from 1672 to 1677 collected plants in the Maritime Provinces and made notes on their uses, which he took with him to Leyden. In 1745, it is said, Hermann's Ceylon herbarium fortunately came into the hands of LINNAEUS, who published an account of the specimens that had survived under the title "Flora Zeylanica".

Thus Ceylon has the honour of possessing one of the earliest published "Floras" based on the Linnaean System, and that written by Linnaeus himself.

Dutch Interest

Interest in Ceylon botany was maintained throughout the Dutch occupation. Seeds and fruits were sent to Holland from time to time, and the idea of a Botanic Gardens may be said

to have originated with the Dutch. There is evidence to show that they maintained a garden somewhere in Slave Island (Colombo) in the 1790's.

The Peradeniya Gardens, 1822

(*a*) *Site*

The Peradeniya site, 68 miles from Colombo, was finally selected in 1822, in the early stages of British administration, by Governor Sir Edward Barnes. There were at least three changes of site prior to this.

The Dutch Garden had fallen into disuse, no doubt in the transitional phase of war with the British, but in 1798 the first English Governor, the Honourable Frederick North, ran a small private garden at Peliyagoda, near Colombo, under the superintendence of Joseph Joinville.

In 1810 Sir Joseph Banks, then President of the Royal Society, was instrumental in getting opened the first English Botanic Garden in Ceylon with W. Kerr as Superintendent. This consisted of 7 acres of land in Slave Island, named after Kew Gardens, and the site is still indicated by Kew Road. Kerr was also placed in charge of the garden at King's House as " Resident Superintendent and Chief Gardener ". His successors to this day exercise general supervision over all Governor's gardens.

In 1813 the garden was moved to Kalutara (26 miles away), the Colombo site being found to be subject to frequent flooding. Alexander Moon was put in charge in 1817. Under him the gardens were much improved, and, in 1822, at the direction of Governor Barnes, the site was finally removed to Peradeniya.

Thus the premier garden of the East was finally located in a site rich in historical associations as the fruit garden and pleasure grounds of Sinhalese royalty down to the fall of the Kandyan kingdom. Emerson Tennent records that even as early as 1371 a Sinhalese King is said to have held court at " Piradeniya, situated near the river Mahaweliganga ".

It is believed that this Governor's intelligent anticipation of a great future for coffee inspired the site in mid-country, almost at the gateway of the rising commercial estates. Thus a link was forged at the very inception between a pure scientific outlook and the practical agricultural approach that the neighbouring Gangaroowa estate, opened in 1825 as the first coffee plantation on a large scale, was able to inspire. This estate of over 550 acres was later to be absorbed as the Experiment Station of the Gardens.

" Moon transferred to Peradeniya all the plants which could be moved from Kalutara, and laid out the south-eastern part of the ground, planting especially coffee and cinnamon. In 1824 he published in English and Sinhalese his " Catalogue of

the Indigenous and Exotic plants growing in Ceylon". He made a considerable herbarium, now mostly at Kew, and commenced the library of the Department.

"In 1818 Harmanis de Alwis Seneviratne was appointed writer under him, and displayed such talent for drawing that Moon had him taught at his own cost and appointed as draughtsman in 1823. This was the beginning of the splendid series of coloured drawings of the Ceylon flora and of other plants cultivated in the gardens which has been steadily continued to the present time by H. de Alwis, his two sons, William and George, and his grandson, Alfred, who is at present the draughtsman of the Department" (HERBERT WHITE in 1909).

The association of this family with the Department of Agriculture is unbroken to this day, 123 years after that first appointment, the present representatives being Mr. E. de A. Seneviratne of the Entomological Division and Mr. D. de A. Seneviratne of the Veterinary.

The nearest parallel to it is that of the continuous association of the NOCK family with Hakgala Gardens from 1882 to 1940. The first of these, William Nock, is still living, at the advanced age of 92.

The lines of development of the Gardens from then on are thus summarized by Herbert White :—

"In many ways the history of its gradual enlargement reflects the general history of the 19th century in Botany and its allied sciences and arts. In the early years of the past century, when Botany consisted only of the study of the external characters of plants, their classification, and the investigation, naming, and cataloguing of the plants of the different regions of the world, the Royal Botanic Gardens of Ceylon were occupied principally with the collection and description of the world flowering plants and ferns of the Island, and with the gradual accumulation at Peradeniya of as many as possible of these. This has resulted in the formation of a great herbarium and museum of Ceylon plants, a very complete collection of living specimens in the various gardens, publication of a Flora of the Colony, the final volume of which was completed in 1900.

"A solid foundation was thus laid for the further investigation of the flora of Ceylon by agricultural and economic botanists, vegetable physiologists and pathologists, and other workers."

(*b*) *Research and Staff*

In 1825 Moon died of fever. From this time till 1844 the Gardens languished, and were put to rather humiliating use by Government as a market garden, the produce of which was sold in Kandy ! One drawback apparently was the selection of the earlier superintendents after Moon rather for their horticultural attainments, no doubt with a view to promoting the preliminary

lay-out, although the terms of their appointment included "making discoveries in botany" and "forming a herbarium of dried plants for the future use of the establishment in Ceylon".

In 1844, however, the true scientific era began with a series of appointments which brought Ceylon to very prominent notice among tropical countries. GEORGE GARDNER, the well-known Brazilian explorer and traveller, took charge in 1844. He brought out to Ceylon a large herbarium and a good botanical library. Though death cut short his career at the early age of 37 only five years later, his work on Ceylon Flora was substantial enough to be a credit to his memory.

GEORGE HENRY KENDRICK THWAITES, who arrived in 1849, was a botanist with an established European reputation already for his investigations on *Algae* and *Diatomaceae*. He made numerous collecting tours in the Island and discovered a number of new and interesting plants, many of which were described in papers in *Hooker's London Journal of Botany*. In 1858, he began the publication of a catalogue of Ceylon plants, *Enumeratio Plantarum Zeylanicae*, which was completed in 1864.

"For thirty-one years (1849–1880) he was to control the destinies of the Department, and to do much for scientific botany and for the planting industries of Ceylon. Until about 1857 his duties were largely of a purely scientific kind, but afterwards his time was increasingly taken up with economic work, chiefly the introduction, acclimatization, and extension of new economic products."

In 1880 Thwaites was succeeded by HENRY TRIMEN, a well-known botanical writer then holding an appointment as Assistant in the Botanical Department of the British Museum. Trimen addressed himself to the task of preparing a full descriptive flora of the Island, supplementing the work of Thwaites, which he did with great thoroughness.

"Thus thanks to the labours of Thwaites and Trimen Ceylon possessed at the close of the last century a more complete knowledge of its flora, whether phanerogamic or cryptogamic, than any other tropical country.

"At the same time the work of the Director of the Botanical Gardens had now definitely become that of an Agricultural Adviser to the Ceylon Government and to planters, and Trimen's Annual Reports show that he kept that view of his duties always in the foreground." (*Gardens Centenary Number*).

In 1896 Trimen was succeeded by J. C. WILLIS, one time Senior Assistant in Botany in the University of Glasgow. Under him the work of the Gardens underwent rapid transformation and the new outlook was clearly endorsed by the publication in 1897 of a periodical entitled "Circulars of the Royal Botanic Gardens, Peradeniya" for economic questions, and in 1901 a scientific botanical journal, *The Annals of the Royal Botanic Gardens, Peradeniya.*

Thus under the guidance of scientists of international fame the "Peradeniya Gardens" paved the way for an Agricultural Department based on wider principles early in the 20th century. To many now living, names like Gardner, Thwaites and Trimen have almost a legendary ring, and Thwaites in particular with a reputation for habits of seclusion, is remembered as a spare figure sparely seen on his trips home from work, notoriously not for rest, but for more in the recesses of his study.

(c) *Expansion and Growth from 1850*

(i.) Branch Gardens

"Among the numerous introductions throughout the 19th century may be mentioned—cocoa, cinchona, india rubber, Liberian coffee, vanilla, a vast number of plants of minor importance, new varieties of fruits, vegetables, and flowers, shade and timber trees, &c., while the spread of the cultivation of tea, cloves, nutmegs and many other things has also been largely helped by the introduction of good kinds through the Botanic Gardens." (Herbert White.)

As the work at Peradeniya developed and expanded Branch Gardens were opened in the different climatic zones. Among the most important of these were :—

HAKGALA, which Mr. William Nock was later to develop into a "mountain garden unrivalled in the Tropics", was established in 1860 as a nursery for cinchona, and in due course extended for the acclimatization and trials of trees, shrubs and plants suitable for the cooler and higher elevations, *e.g.*, acacias, conifers, eucalyptus, camphor, European and Australian fruits and vegetables.

In 1901 a small laboratory was opened for the use of scientific workers, with sleeping accommodation, and in 1921 a rockery.

HENARATGODA was opened in 1876 for the accommodation of the recently introduced rubber plants (*Hevea brasiliensis*) which laid the foundation of a flourishing planting industry. Small plantations of mangosteen, kola, cinnamon were also made. Some fine specimens of tropical trees are also to be seen in these Gardens, and a feature of considerable interest is the female plant of coco-de-mer.

ANURADHAPURA was opened in 1883 for trials with trees and shrubs suitable for the dry zone, but had to be closed in 1906 when the Department decided to pay greater attention to economic agriculture. This now forms the park-like grounds of the Grand Hotel so familiar to circuit officers who lodge there.

BADULLA was opened in 1886 to demonstrate that rubber could be grown in Uva, closed in 1906, and now forms the park of the Urban Council, Badulla.

Among other introductions were fine timber trees such as sandalwood (*Santalum album*) which seeded freely and spread naturally in Uva.

NUWARA ELIYA was in 1902 for trials with conifers and horticultural plants.

The floral garden scheme with the beautiful ponds was the special care of William Nock from Hakgala Gardens, and these curators held charge till October 1, 1929, when the local authority took over what had already become the well-known Park of this sanatorium.

Of historical interest to the Peradeniya Gardens are :—

The opening of the New Peradeniya Railway Station in 1889, specially intended for the convenience of visitors to the Gardens ; and the building of a Resthouse in 1901 intended primarily for the accommodation of visitors to, and scientific workers in, the Gardens. As a sort of vestigial privilege to-day, even under Provincial Road Committee administration, occupation rules are relaxed, and two rooms are always available for scientific workers coming to make a prolonged stay to undertake research.

(ii.) Organization

In 1857 the title of Resident Superintendent was changed to Director, Thwaites becoming the first.

In 1860 the post of Curator was created to relieve the Director of routine garden work, W. Cameron being the first. Since then the purely "garden" work has been ably superintended by a succession of Curators, the post outliving the creation of the new Department in 1912.

H. F. Macmillan, who joined in 1895 as Curator, is well-known for his authoritative book on "Tropical Gardening and Planting" which he wrote with special experience and knowledge of conditions in Ceylon. In 1913 for a brief period after the creation of the new Department the post of Superintendent was revived with Macmillan as the holder, but lapsed with his retirement in 1925.

The present Curator is Mr. T. H. Parsons, who has seen continuous service since 1914, bred like many of his predecessors in the tradition of KEW. The present handbook on the Royal Botanic Gardens, Peradeniya, was prepared by him.

In 1883 the Director's bungalow in the centre of the garden was turned into a museum.

As mentioned earlier, J. C. Willis was the last of the Directors of the Gardens Department. When he arrived in 1896 the Department was still botanical, and that mainly systematic. An indication of this persistent pure botanical bias is seen in the postponement of the appointment of an Economic Botanist till 1919. Till then the Director was also in effect Botanist with a Scientific Assistant to help him.

The first step towards "modernization" was the establishment in 1897 of the "Circulars" referred to earlier. These were brief popular accounts of current topics on agriculture, horticulture, entomology or botany, published as occasion required.

The first expansion with Staff took place in 1897 when Mr. John Parkin was appointed Scientific Assistant to work on Para rubber, and the growth of a great new industry followed two important discoveries made by him and the Director Dr. Willis in the method of tapping and preparing rubber.

In 1899 E. E. Green, who later became a well-known authority on Coccidae and author of *The Coccidae of Ceylon* was appointed permanently as Entomologist. He investigated the principal pests of tea, cocoa, coconuts and paddy in Ceylon. For his meritorious work he was awarded the Barclay Medal in 1901.

In 1900 J. B. Carruthers was appointed Mycologist, and investigations into the canker disease of cocoa were continued. Other diseases such as canker disease of rubber, branch canker of tea, root diseases of tea, were also investigated. In 1905 he was succeeded by T. Petch, who had worked on fungi for 15 years before his appointment. As we shall see later, he thoroughly examined the earlier collection of fungi from Ceylon, and was responsible for several standard publications.

In 1880 Mr. H. Marshall Ward, who later became Professor of Botany at Cambridge, had been appointed for a period to investigate the disease fungus of the coffee leaf—the first appointment of an official mycologist in the British Empire. He published many valuable reports.

"The damage caused by fungus diseases is often considerable and may sometimes completely prevent the growth of certain crops. There is the classic example of the coffee leaf disease, caused by the fungus *Hemileia vastatrix*, which was the main cause of the ruin of the coffee-planting industry in Ceylon towards the end of the last century. The damage caused by this disease led to an appreciation of the importance of tropical plant diseases and, since the beginning of the present century, there have been mycologists and plant pathologists in most countries who have studied plant diseases and who have endeavoured to discover means of checking their ravages." (Malcolm Park, Pathologist and Acting Deputy Director, in *Diseases of village crops in Ceylon*, 1941).

Peradeniya soon became a recognized centre of mycological knowledge.

In 1900 M. K. Bamber became the first Agricultural Chemist. The chemical and physical properties of Ceylon soils were investigated, and trials and investigations made as to the manurial requirements of various crops. Bamber was mainly

responsible for the spread of green manuring throughout the Island. The Tea industry is said to owe much of its present-day methods of cultivation to his efforts.

During 1900 the new laboratory at Peradeniya was opened.

(*d*) *Experimental Station at Gannoruwa, 1902, and the Committtee of Agricultural Experiments*

The year 1902 constitutes a turning point and a landmark with the establishment of the Experiment Station at Gannoruwa, on the opposite bank of the Mahaweli-ganga, sited on the former Gangaroowa estate of 550 acres, then partly under cocoa.

It was no longer worthwhile merely to know that a particular "economic product" *would* grow in Ceylon. It was equally, if not more, important to know the best methods of cultivation and of preparation for market. This involved cultivation and preparation on a commercial scale to test the resulting products by sale in the open market; and such experiment was more suited to a scientifically equipped institution which was not obliged to show profits.

The Administration Report for the year states :—

"The need for such an experiment station has long been felt, and the site chosen gives every promise of this, the first British Tropical Agricultural Experiment Station on any scale, being of the greatest value to Ceylon in the first instance, and in some measure to the whole Empire. The fact that the Station adjoins the Royal Botanic Gardens will enable the Director and his colleagues effectually to superintend the various experiments carried on without loss of time.

"The object of the station is to add to our knowledge of economic products by using scientific methods in experiment and observation. Such questions as the best methods of cultivation of plants already being cultivated for profit with a view to improving these; the prevention and cure of the diseases associated with cultivated plants; the introduction of new and untried plants of possible economic value; the improvement by selection and other scientific methods, of economic plants; the determination of the value of various manures for different crops; the value of shade for each product; and the best trees and numbers of them to be used.

"Mr. Herbert Wright, A.R.C.S., at that time Scientific Assistant and Acting Curator of the Peradeniya Gardens was appointed Controller of the Station."

In order that the best technical advice and help might be available in carrying on its work a COMMITTEE OF AGRICULTURAL EXPERIMENTS was appointed with the Director as President, and the Senior Scientific Staff and a few unofficials, including planters, as members.

Since the opening of the Station the agricultural experimental plots in the Gardens were no further extended, and some of the plants were transferred to the Experiment Station. The Royal Botanic Gardens was in future to deal mainly with horticultural plants, leaving the trial and experiment of agricultural plants to the Experiment Station.

Its achievements up to 1922 were thus summarized in the *Gardens Centenary Number*:—

"The work on this Station has been of the greatest value to the planting industry. Manurial experiments with various crops are being carried out, tapping experiments with rubber systematically conducted, the cultivation of cocoa studied, the value of green manuring in tea demonstrated, yields of lemon grass investigated, trials being made with many crops of economic importance and in recent years detailed investigations, from the point of view of the economic botanist, have been begun in respect to the individual yields of rubber of known parentage, the variation of individuals of cocoa of known parentage and to the selection and improvement of paddies."

The Peradeniya Experiment Station served as an excellent model for many more in other appropriate parts of the Island, and inspired ultimately the establishment of Research Schemes for tea in 1925, coconut in 1928, and for rubber in 1930. Although the major agricultural industries now depend little on this Station for results (with the exception perhaps of experimental work in budded rubber at the Iriyagama Division) it subserves a very useful purpose to this day for work on annual crops, fodder and pasture grasses, and coffee, cocoa, and fruits.

Above all, it has been closely linked with agricultural education at Peradeniya since the opening of the School there in 1916, being the experimental ground and demonstration plot (*e.g.*, soil conservation measures in recent years) for many a future agriculturist.

B.—THE GOVERNMENT AGENT ADMINISTRATION, 1833

In 1833 the Government Agent regime was established by the British Government. With powers almost approximating to those of an old-time Dissawa, or Governor of a Province, the Government Agents were the lineal legal descendants of the Collectors or Agents of Government in the Maritime Provinces, and of the Revenue Commissioners of the Board of Commissioners for the Kandyan Provinces.

This system, subject to political and constitutional changes from time to time, has persisted to this day.

The following is a Blue Book definition of their duties :—

"Collecting the revenue, suggesting improvements in the mode of collecting it, to hear and settle all disputes arising in the management of the different revenue farms, *in the*

superintendence of agricultural pursuits and the sale of Government waste lands, and to communicate to the inhabitants the orders of Government."

Their patriarchal, or quasi-parental, authority in the provinces for many decades made them the very pivot of the British administration. Many questions now almost exclusively handled by technical departments came within their purview right up to the end of the 19th century. A notable example is Irrigation. When the restoration of Irrigation Works became almost a passion with Governor Ward and Governor Gregory in the latter half of the century the first thought was not the creation of a new Department so much as a new Province (the North-Central Province under Government Agent Dickson). Till the creation of the Irrigation Department in 1900 work in the provinces was entrusted to Provincial Irrigation Boards with Government Agents as ex-officio Presidents, although the Public Works Department (established in 1867) did some of the technical work.

So it was with Agriculture, especially rural agriculture. Paddy and *chena* were the main sustenance in the villages, and with Government Agents in control of land and revenue (including the Paddy Tax) it was but natural that rural agriculture should come peculiarly in their purview. Famines, floods, pests and pestilences were subjects of their paternal care to avoid ; so what more natural than for them to scan the agricultural horizon to see that crops were grown, did not fail, and made men full ?

One of the main arguments against a new Department in 1899 was that the peasant would be less amenable to a technical Department than to the Government Agents and the Headmen System.

" There is in every Province a Government Agent, his assistant, his native executive staff. I do not think that a Board of men, however able and scientific, could do much good unless it was in touch with, and had control over, the local headmen.

" It seems to me that the proposal that a scientific department at Peradeniya should control agriculture in the villages is not practicable.

" *We cannot ignore or disregard the existing administration so long as it lasts and so long as it is strong as it is now, it would be useless to create a new department which would be powerless to face the strength of the Government Agents and their officers.*" (Chief Justice Lawrie.)

A member of the Civil Service, Mr. W. E. Davidson, who was one of them said :—

" I am not in favour of an Agricultural Department, at least so far as it would affect the agriculture of the peasantry.

"It would add one more bond of centralization which would tend to hamper the individual action of the Revenue Officer, who alone is in direct touch with the cultivator, and who works best when left to follow his natural bent."

This line of argument was one of the major factors that torpedoed the recommendation of the 1899 Commission and delayed the new Department till 1912.

However, as we shall see presently, an unanswerable argument loomed large, and the following case for CONTINUITY, put with considerable humour and resource in a memorandum by Mr. John Ferguson, ultimately paved the way :—

"The great defect hitherto has been the absence of continuity of work. One officer's fad is irrigation ; another's gardening ; another's stock improvement ; another's paddy or coconuts. Owing to the frequent changes in administration each man's scheme, good in itself, is gradually dropped by his successor.

"Our stations are full of neglected sites where some civilian started an experimental garden and the next man let it die out.

"One officer has a taste for agriculture ; he knows about live stock ; he is fond of riding round and is interested in what the people are doing. His successor, being altogether a student before coming out to Ceylon, does not perhaps know a cow from a bull, never rode a horse, and cares nothing for agriculture in any form or farm."

C.—THE CEYLON AGRICULTURAL SOCIETY (1904)

On October 28, 1904, His Excellency Sir Henry Arthur Blake presiding, in the presence of a large gathering, The Ceylon Agricultural Society was founded.

The Hon'ble Mr. John Ferguson, C.M.G., proposed :—

"That a Society shall be formed to encourage the advance of the agricultural community by improved methods of cultivation, and more useful selection in stock breeding and such other means as may suggest themselves to the Society."

The seconder was Dr. H. M. (later Sir Marcus) Fernando, and the motion was carried unanimously.

The Hon'ble Dr. Rockwood then moved :—

"That a Board of Agriculture be formed to consist of the following ex-officio members, with H. E. the Governor as President.

The Members of the Legislative Council.
The Government Agent of each province.
The Director of the Royal Botanic Gardens.
The Director of Public Instruction.
The Colonial Veterinary Surgeon.

together with members to be nominated from the Society.

Mr. (later Sir William) Duff Gibbon seconded.

The Administration Report of the Director, Royal Botanic Gardens, for the year records :—

" The object of establishing this Society is to get at the native cultivator, and especially the villager, by means of the wealthier local landowners and planters, and to bring to the hand of every one who wishes it the experience and knowledge of the various branches of agriculture possessed by the Peradeniya staff, the Government Veterinary Surgeon, and other officials, and as far as possible also that of the various experienced planters and agriculturists belonging to the Society."

Governor Blake with his experience in Jamaica is said to have been the main inspiration for this Society. One had been organized there in 1895.

Thus, despite the failure of the 1899 Commission, the minor gulf between plantation and rural agriculture was happily bridged, and the remarkable enthusiasm of the European community, among them John Ferguson, and Crosbie Roles of the *Times*, was a happy augury. Wealthy landowners and other prominent gentlemen among the Ceylonese like Hulugalle Adigar, S. C. Obeysekera, J. W. C. de Soysa, S. D. Bandaranaike, James Pieris, A. E. Rajapakse, H. L. de Mel, W. A. de Silva, William Dunuwille, A. Kankasabai, Francis Beven, J. D. Vanderstraaten, P. Arunachalam, C. E. A. Dias, J. H. Meedeniya, L. E. Blaze and D. S. Senanayake were original members.

The subscription was Rs. 5 a year, which entitled members to a free copy of the official Magazine.

Starting with 200 in the first year the membership was later to rise to over 2,800 (including foreign members who joined as subscribers to the Magazine of the Society), and with the addition of Rs. 30,000 annually from Government the Society was able to run a minor Department.

For nine years even after the establishment of the Department of Agriculture, its field organization, yearly expanding, functioned efficiently and independently, till in 1921 under the Territorial Organization Scheme of Director Stockdale the staff was absorbed into the official and now reorganized Department.

The Board of Agriculture was the Executive with several committees, such as finance, education and publication, livestock, paddy cultivation, exhibition, to assist in special branches of work. Its first secretaries were civil servants of the calibre of E. B. Denham, and A. N. Galbraith, and in 1907, Mr. Christie Drieberg, Superintendent of School Gardens, assumed the office in addition to his own duties.

The early field agricultural and other staff have interesting links with the present day. Among the 3 first appointed—2

for Sinhalese districts and 1 for Tamil—was Mr. (later Mudaliyar) N. Wickramaratna now active in retirement on a differently constituted Board of Agriculture. In 1909 a Kandyan Instructor was appointed for the first time, and the choice was Mr. W. Molegode, now energetic Propaganda Officer of the Department. Among the first of the clerical staff was Mr. W. A. W. Gunawardena, now at the top of the Head Office clerical staff.

The enthusiasm of the progenitors never waned. Numerous local societies sprang up throughout the Island. Governors regularly presided at Board meetings, Sir Robert Chalmers often holding them at Queen's House. Wealthy members readily subscribed to promote exhibitions throughout the country, by the Province, District or Division. (The Nuwara Eliya Agri-Horticultural Show, still an annual feature, is a legacy of those days.) Wherever the Instructors worked, government agent and assistant, chief headman and minor, priest and parson, planter and pedagogue all readily co-operated and assisted.

Among the many achievements of the Society in the villages were the introduction of new paddy varieties, cotton, grapefruit and White Burley tobacco, apiculture and sericulture, and successful demonstrations with green manuring and with transplantation of paddy, supplying of planting material, popularization of the light iron plough, and even improvement of livestock, for which its Instructors were given some technical training to supplement the work of the Stock Inspectors of the Veterinary Department whose duties were mainly associated with the preventive and curative sides of disease.

The relations of the Instructors of the Society with the School Garden Staff (transferred to the Department of the Botanic Gardens in 1906 and absorbed into the new Department in 1912) continued cordial owing to the happy accident of its Secretary being also the Superintendent of School Gardens. This, with other factors such as the presence of the Director and other technical staff on the Society's Executive Board, promoted a healthy parallel development till the Reorganization Scheme of 1921 rendered the Society more or less superfluous.

PUBLICATIONS

There was considerable dissemination of information through magazines and leaflets in the three languages, among a host of subjects covered by the latter being—

Catterpillar pest in paddy fields,
Castration of Cattle,
Cotton Experiment Stations,
Shade trees and how to plant them,
Tobacco cultivation in Dumbara, &c.

The Society published the first issue of its English Magazine in combination with the *Tropical Agriculturist* in February, 1905 ; a Sinhalese edition *Govikam Sangarawa* in July, 1905, and a Tamil the *Kamat Tholil Velakkam* in January, 1906.

The Tropical Agriculturist had been founded in June, 1881, by Mr. John Ferguson, the foster-father of the Agricultural Society. One of the very first publications of the kind, it had received a warm welcome from Dr. Trimen of the Peradeniya Gardens, the Kew authorities, the West Indies and islands of the Pacific, South America, Africa, California and Florida. Only three years later, its founder had the pleasure of hearing the Agricultural Department at Washington eulogize it, " prizing this East Indian publication above most coming into their office ".

" But without going any further ",

said Mr. Ferguson in a virtual swansong in February, 1905, " into the vast amount of interesting and useful information which this first volume as well as subsequent issues of our ' T.A.' contained we must now turn to the duty more immediately before us of announcing the amalgamation of our periodical with the ' Magazine of the Ceylon Agricultural Society'. This Society was bound to have a representative organ to justify its existence and to afford necessary information to its members. Dr. Willis and his Scientific Staff at Peradeniya, with technical experts in other official departments, were ready to conduct, and contribute to the same, and we at once recognised that two agricultural monthlies would be out of place in Ceylon, and that it would be far better to coalesce forces, utilising certain features of the ' T.A. ' and making the most of the prestige it has acquired, especially outside of this island. "

Dr. Willis assumed the responsible editorial charge, and the founder " practically severed his personal connection " after a continuous association of 25 years.

FODDER.

M. CRAWFORD, M.R.C.V.S.,

GOVERNMENT VETERINARY SURGEON.

ONE of the weaknesses of Ceylon methods of cattle breeding is the almost complete absence of the practice of storing and using straw or hay for the feeding of cattle during seasons of scarcity. Practically the only straw ever saved and fed to cattle is paddy straw ; even that does not apply to all parts of Ceylon. The greater part of Ceylon's cattle population has to depend on grazing with consequent annually recurring periods of semi-starvation.

The value of straw or hay is not realized and little or no attempt is made to grow, harvest and store supplies of material to be used for feeding cattle.

A very different state of affairs exists in India. Since the climatic and soil conditions of parts of South India are not too unlike those of parts of Ceylon it is of especial interest to have some knowledge of the methods in use in that part of the world.

Throughout Littlewood's most interesting book on the Livestock of Southern India, there are numerous references to the fodder problem as it affects different parts of Southern India. Practically all the crops grown to provide fodder for cattle n South India grow, or could be grown, in some part or other of Ceylon. The following notes have been collected from Littlewood's book with the object of stimulating interest and encourging experiment in Ceylon with a view to increasing the fodder supplies not only in quantity but in variety.

Littlewood has much to say on grazing practices in Southern India ; but these notes will deal only with fodder crops and especially with residues of cereals and pulses which can furnish valuable food for cattle.

Cholam.—This appears to be one of the main fodder crops of Southern India. In some places it is grown purely as a fodder crop but this is not a general practice. Where it is grown as a purely fodder crop the seed rate is much heavier than is the case when it is grown for the grain. This gives a heavier yield of fodder and the stems are thinner and so more suitable for cattle. In the Ongole and Guntur areas cholam is grown mixed with sunnhemp as a purely fodder crop. It may also be sown mixed with a pulse. It is said to be sown at a high seed rate in July and August and cut and fed green up to the end of December. In most cases cholam is grown as a grain crop the straw only being used for feeding cattle.

Another practice mentioned is to sow at a high seed rate and thin out the young plants to be used as green fodder leaving the remainder to mature as a grain crop. The tops of cholam after removing the grain are also used as fodder.

Sunnhemp.—Is grown and fed to cattle either green or as hay. In the delta tract it is sown for fodder following paddy. Large quantities of sunnhemp hay are said to be sold from the delta area for feeding cattle on dry lands. The exact manner in which cuttings of green sunnhemp are taken is not quite clear but it appears that it is possible to take more than one cutting. Apparently cutting is started at one end of the plot when the crop is half grown and cuttings are made daily thereafter proceeding from one end of the plot to the other.

Cumbu.—It is stated that the main unirrigated cereal crop of the Dharapuram taluk (that is within the area where Kangayam cattle are bred) is cumbu and the straw forms the main fodder supply in that place. A special 4-months variety with a branching habit known as "nadam" cumbu is used and is sown in July-August. This variety has a fine straw and plenty of leaf. The straw is harvested when the dew is on it for two reasons: (1) the leaf is not brittle and does not break off and (2) the moisture supplied by the dew makes the fodder more succulent when it is stacked. With cumbu a pulse is usually sown and the straw of the pulse is mixed with the cumbu straw. In other parts cumbu straw is not so highly prized as other straws but is used when obtainable.

Kurakkan.—The straw of this is considered as good as paddy and meneri straw and is apparently used as fodder in all parts of Southern India. In some parts it is considered superior to paddy straw.

Panicum miliaceum (*Meneri* S.).—The straw is prized in the area where Ongole or Nellore cattle are reared. In that part it is said to be the only dry land cereal grown in the north-east monsoon. This straw is said to give a soft and shining coat to the cattle. The husks of the meneri grain are used as cattle food. The fact that this straw is largely used for feeding such a noted breed of cattle as the Ongole would indicate that it is very nutritious.

Setaria italica (*Tanahals*).—This is grown on the black soils of the Ceded Districts. The straw is said to be a specially valuable fodder.

Other cereals.—The straw of the *Pennisetum typhoides*, *Paspalum scrobiculatum* (*Amu* S.) and of *Panicum miliare* (*Hinmeneri* S.) are also used in parts of Southern India as fodder for cattle.

Pulses.—The straw, husks and pods of pulses are prized as fodder for cattle and are carefully collected and stored. Among the pulses grown; cowpea, horsegrain and *Phaseolus trilobus* (*Bin-me* S.) are prized as cattle fodder. Littlewood states that the greatest care is taken to collect the leaves and pods after the pulse crop is harvested: the fields are often swept so that none of the fallen leaves should be lost. In the Ongole tract it is stated cowpea is sown early in the season and after a cutting is taken for fodder the crop is allowed to grow on for grain.

In addition to the cereals and pulses described above cotton is largely grown and the cotton seed is used for cattle feeding. It is not definitely stated but from the context it would appear that some of the cotton is ginned in the village instead of at large mills. That practice would of course save the cost of transport of the cotton seed back to the village after ginning.

The following extract is given to show the care taken by breeders and as an example of the kind of methods we shall have to inculcate in Ceylon.

EXTRACT

"In Ongole district bull calves are given some soft green grass after about 40 days old and a month or two afterwards some good green fodder if available. Sometimes a little grain, such as cholam is ground up, boiled in water and then fed. After weaning, sorghum and horsegrain is pounded and made into a paste along with water in the form of a thin gruel twice a day. If the quantity is limited the calf is only fed once a day at 3 P.M. At 20 to 24 months the young bull is trained for work and at the age of 2½ years light work is given and this gradually increases until the animal cuts its second pair of teeth. *Most of the grain consumed is produced on the homestead* and it is very rare that the ryot purchases grain for this purpose."

That is the way the fine Ongole cart bulls are produced.

Reference : *Livestock of Southern India* by R. W. Littlewood, N.D.A. Published by Madras Government Press (1936).

COCONUT RESEARCH SCHEME

PROGRAMME OF EXPERIMENTS FOR 1942

THE following research programme for the year 1942 has been adopted by the Board of the Coconut Research Scheme :—

A.—Geneticist's Department.

I.—*Bandirippuwa Estate.*—

(*a*) *Yield Records.*—These will be continued on Geneticist's Blocks A. & B. and on the selected seed palms.

Objects.—(i.) To ascertain the relation between climate, particularly rainfall, and the physiological activities or palms of high, low and average yielding capacity.

(ii.) To isolate high yielders for provision of planting material.

(*b*) *Dwarf Palms.*—Detailed records on 12 dwarf palms will be continued.

Object.—To study on a small scale the development, the earliness of maturity, period of economic production and yield of the green dwarf palm.

(*c*) *Nurseries.*—A uniformity trial with seedlings in the nursery ; observations will be continued.

Object.—To obtain data on the natural variation of seedling growth, which will enable experiments—such as manurial trials on seedlings—to be planned with greater accuracy.

II.—*Co-operative Experiments.*—

(*a*) *Yield Records.*—Record on 28 estates, containing approximately 2,000 palms will be continued.

Object.—To extend the selection of high yielders on private estates for the purpose of supplying good planting material.

(*b*) *Experimental Plantations : I.—Plantation I.*—Recording work on this will be continued.

II.—Recording on this secondary plantation has been discontinued on the Board's instructions.

Object of I.—To study the nature of segregation of characters in relation to yield of proved high yielding palms.

III.—On the Matale plantation occasional records will be continued.

Object.—To study the performance of selected seedlings planted on a fairly large scale under private management in the Matale district.

III.—*Ratmalagara Estate.*—

(*a*) *Field Experiment I.*—Records on this experiment will be continued during 1942.

Object.—To compare the performance of selected and unselected seedlings from proved high yielders, proved low yielders, and nuts picked at random from estate heaps.

(*b*) *Dwarf Palm.*—Observations will be made on the area of dwarf palms planted up in 1940, which has been continued in 1941 to 10 acres (about 900 palms).

Object.—As in I. (*b*) on a field scale.

(*c*) *Field Experiment 2.*—Commencement of the experiment included in the programme for 1941 (A. III. *b*), has again been postponed, for reference to the Board in view of the Scheme's financial position. The expense of clearing an area for this experiment and of its upkeep would be considerable and the adequate control of the experiment would entail the appointment of another Field Assistant.

B.—Soil Chemist's Department.

I.—*Field Experiments.*—

(*a*) *Bandirippuwa Estate.*—(i.) *NPK Manurial Experiment.*—Yield recording on this experiment will be continued in 1942, the eighth year of the experiment.

Object.—To determine the response of mature coconut palms to the three manurial constituents, Nitrogen, Phosphoric Acid and Potash, at the levels nil, single and double doses of each combined in all possible ways.

(ii.) *Cover Crop Experiment.*—Records to be continued during 1942.

Object.—To determine the effect on mature coconuts of growing a cover crop and treating it in different ways, with and without fertilizers.

(*b*) *Ratmalagara Estate*: (i.) *Combined Manurial and Cultivation Experiment.*—Records will be continued in 1942.

Object.—As in I. (*a*) (i.).

(*c*) *Manurial Experiments on other Estates.*—

(i.) *Veyangoda.*

Object.—As in I. (*a*) (i.) with simpler manurial treatments but the addition of husk burying treatments.

(ii.) *Southern Province.*

Object.—As in *c* (i.). Yield recordings on these two experiments will be continued in 1942.

(iii.) *Fodder Grass Experiment.*

Records on fodder grass harvested and on the yields of the coconuts will be continued.

Object.—The object of this experiment is to study the effect on mature palms of growing fodder grass beneath them, and of various fertilizer treatments continued with the fodder cultivation.

(iv.) *Manurial Experiment on Underplanted Seedlings.*

Observations on this experiment at Letchimey estate, Nattandiya, will be continued in 1942.

Object.—To determine the effect of manurial treatments and cover crops on underplanted seedlings with regard to growth, early bearing, &c.

II.—*Laboratory Investigation in connection with Field Experiments.*—

(i.) Soil analyses will be done as exigencies permit on samples from the N. P. K. and cover crop experiments. Emphasis was laid in 1941 on phosphoric acid. Potash will be particularly studied in 1942.

Objects.—To study the effect on soil composition of nature of fertilizer treatment and cover crop treatment.

(ii.) Analyses of husks and coconut water samples from the plots of the NPK experiment for potash will be continued, with the addition of fronds and bunch stalks.

Object.—To study quantitatively the potash uptake of the palm.

III.—*Other Investigations.*—

(*a*) *Potash Salts from Husk Ash.*—Experiments, which on a laboratory scale have been successful, will be continued on a larger scale.

(*b*) *Nutfall.*—Preliminary investigations carried on by the Department of Agriculture on this subject have been referred to the Scheme for continuation and expansion. It is hardly possible at present to set this out in a research programme in a formal manner, as the early work must be observational.

C.—Technological Chemist's Department.

I.—*Laboratory Investigation in collaboration with other Departments.*—

(*a*) *Germination Experiment No. 2.*—In the first experiment in 1941 the germination of the coconut was studied up to 30 weeks and interesting results obtained, particularly with reference to the distribution of moisture, total dry matter, nitrogen and potash.

It is proposed in 1942 to carry out a further experiment to study the change over a longer period, with special reference to phosphoric acid and the organic constituents (oil, sugar and cellulose). This will best be commenced late in the year.

Object.—As stated. The first experiment has already supplemented our information on the transplantation and the manurial requirements of young plants, especially with regard to potash, and incidentally (as foreshadowed last year) has yielded particulars of the composition of the apple (at all stages) not previously available.

II.—*Copra Investigations.*—

*(*a*) *White Copra.*—Survey of white copra from different types of kiln on the lines already followed for No. 1, No. 2 and No. 3 copra, including examination of samples from available sources including co-operative societies, and study of keeping qualities.

Object.—As in the previous case, to ascertain what is to be regarded as an acceptable standard of white copra ; and also to assess the efficiency of the various types of hot air driers in use.

If the Board decides to erect a Walahanduwa drier on Ratmalagara estate, work on this will be included under the present head. The patent hot-air kiln at Bandirippuwa estate will obviously be useful.

(*b*) *Individual Variation between Palms.*—Routine analyses by a rapid approximate method will be continued on 100 nuts per pick during 1942.

Object.—To ascertain whether there is a significant difference in oil content between nuts from individual palms and thus whether there is any possibility of attempting breeding for high oil content.

*(*c*) *Attempted Preparation of other Types of Copra* including whole copra (*kotta-pol*) and "crystallized" copra.

Object.—To follow up suggestion made for preparing copra in new marketable forms.

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* Indicates new lines of work on those which have developed from previous work in modified directions.

III.—*Toddy Products.*—

(*a*) *Arrack.*—Continuation of co-operative experiments with the Excise Department and the Government Analyst on arrack distillation.

Object.—To obtain information on the secondary constituents of arrack, particularly those responsible for its aroma ; and the control of these constituents by varying distillation conditions. The ultimate object is to improve the standard of arrack. Up to September, 1941, seven experimental distillations have been carried out at one of the distilleries, and much useful information has already been obtained.

(*b*) *Dwarf Palms.*—Tapping of dwarf palms will be continued.

Object.—To ascertain the average toddy yield of dwarf palms, its composition and therefore whether dwarf palms are likely to be of economic interest for toddy and its products.

IV.—*Other Products.*—

(*a*) *Coconut Shell Tar.*—Further results have been obtained in 1941 on the composition of shell tar and further work is projected in 1942.

(*b*) *Utilization of Charcoal.*—Possibility of wider use of charcoal as fuel by briquetting is suggested for study in 1942.

D.—*All Departments* have a certain amount of laboratory work in connection with inquiries.

Bandirippuwa Estate,
Lunuwila, September 23, 1941.

REGINALD CHILD,
Director of Research.

SELECTED ARTICLES

LIME FOR AGRICULTURAL PURPOSES*

AT the present ime artificial fertilizers are expensive and, in some instances, extremely difficult to obtain. Consequently, farmers are casting about for cheaper substitutes and so run the risk of being persuaded into purchasing not only cheaper but also, unfortunately, inferior fertilizers as is apparent from the numerous complaints continually being received.

These remarks apply particularly to the purchase of lime for agricultural purposes. In this connection the farmer is confronted primarily by one or more of the following questions and without guidance is not always in a position to take the right decision :—

(1) Does my soil require lime ?
(2) If so, what is the most suitable kind of lime to use ?
(3) What quantity is required and how must it be applied ?
(4) What are the characteristics of good agricultural lime ?
(5) What protection does the law afford farmers who purchase such requirements ?

(1) LIME REQUIREMENTS OF SOIL

In so far as question (1) is concerned, soil requires lime—

(*a*) if it is very acid ;

(*b*) if it contains large quantities of iron oxide and alumina which cause applications of soluble phosphatic fertilizers for the most part to revert to less easily available chemical combinations, as generally occurs in the reddish brown leached soils of the mist-belt ;

(*c*) if, owing to certain forms of " brak " or to injudicious cultural practices, the structure of clay or clay-loam soils has deteriorated to such a very unfavourable physical condition that the soils have become sticky and impervious to water or puddles easily and forms hard clods and cracks as soon as it dries out ; and

(*d*) if there is actually a deficiency of calcium for the requirements of certain crops which definitely require " sweet " soil, as in the case of tobacco, and a number of legumes, including lucerne.

From the foregoing it may therefore be concluded that in the great majority of cases agricultural lime should be regarded primarily as a soil corrective and not as a fertilizer, and that, although it does serve as a fertilizer in the

* By A. Marais, Senior Professional Officer, Division of Chemical Services, Pretoria, in *Farming in South Africa*, Vol. XVI.—No. 184, July, 1941.

exceptional instances mentioned under (*c*), its function is solely to supplement an actual calcium deficiency for the plant. Consequently, it can under no circumstances be regarded as a substitute for other essential plant nutrients like phosphorus, potassium (potash) or nitrogen. According to reports received, there are actually people travelling about the country, trying to persuade farmers that certain brands of lime can replace fertilizers like superphosphate. The main object of this article is to warn farmers.

The reason why lime cannot replace other fertilizers is very clear if the following facts are taken into consideration :—

(i.) Owing to the general deficiency of phosphorus in most soils in South Africa, a suitable phosphatic fertilizer is absolutely essential to ensure a satisfactory harvest in the case of the great majority of agricultural crops grown in this country.

(ii.) With the exception of those mentioned under (*d*) most agricultural crops actually remove proportionately more phosphoric oxide (P_2O_5) than lime (CaO) from a morgen of land, as the following few examples will show :—

Wheat	.. ..	23 lb. P_2O_5	and 12 lb. CaO
Oats	.. ..	15 lb. P_2O_5	and 12 lb. CaO
Mealies	.. ..	28 lb. P_2O_5	and 20 lb. CaO
Mangolds	.. ..	28 lb. P_2O_5	and 23 lb. CaO
Beans	.. ..	46 lb. P_2O_5	and 35 lb. CaO

(iii.) Even comparatively acid soils contain more than sufficient lime for the actual requirements of most crops grown on them.

(iv.) Most of the commonly used phosphatic fertilizers such as superphosphate, rock phosphate, super-rock mixtures, guano phosphate, &c., are all calcium phosphates which contain porportionately about 5 parts of phosphoric oxide (P_2O_5) for every 6 parts of lime (CaO).

(v.) The farmer who, in the first instance, regularly uses the ordinary phosphatic fertilizers is thereby at the same time providing, in addition to phosphoric oxide, more than sufficient lime for the actual requirements of most crops.

This explanation, and the assertion that lime can be regarded as a fertilizer only in exceptional cases, will no doubt run counter to the experience of many farmers who have found that applications of lime have actually resulted in increased crop yields, especially on old lands. Closer investigation in such cases often reveals that the increase is due to a more favourable season, better seed, more thorough cultivation of the soil or stricter control of weeds, rather than to the effect of the applied lime. By a process known as " base exchange " in the soil it does happen, however, that comparatively unavailable potash reserves present in the soil are made partially available for the plant by the action of the applied lime and also that the microbial activity in the soil is stimulated in such a manner that phosphates and other soil constituents become more available. In this case it is the essential plant nutrients thus liberated, and not the lime which are responsible for the temporary revival and increase in crop yields. In such cases where lime increases the crop yield, its application amounts in reality to soil piracy. The inevitable result is that land to which lime, and no phosphate, has been applied will be left in

a still more exhausted condition. Unfortunately the so-called "lime-experiments" so often mentioned in testimonials are seldom, if ever, continued any longer than one or two seasons, with the result that not only is the farmer unaware of the fact that with the assistance of lime his soil will ultimately become exhausted, but that by providing agents with testimonials, or by assisting in doing so, he is largely instrumental in misleading his fellow farmers.

It is only natural to conclude, therefore, that few farmers are themselves in a position to judge whether their soil actually requires lime for one or more of the purposes enumerated above. Before a farmer allows himself to be persuaded into using lime as a substitute for fertilizers, especially at the present time when the temptation to economize on his fertilizer requirements is very great indeed, he would save himself much unnecessary expense and disappointment if he first consults the Extension Officer or the College of Agriculture serving his particular area, and if necessary, sent the latter some truly representative samples of his soil to be tested. In most cases this service will cost him nothing.

(2) MOST SUITABLE KIND OF LIME TO USE

In regard to question (2) lime is to-day offered for agricultural purposes mainly in three forms, viz. :—

(*a*) Calcium carbonate ($CaCO_3$), the finely pulverized natural limestone which ought to contain 100 per cent. $CaCO_3$ in the pure state. High quality calcium carbonate should contain at least 90 per cent. $CaCO_3$ or more than 50 per cent. CaO. This is the cheapest, safest and most common form of agricultural lime. Farmers are sometimes advised to use on acid or ferruginous soils superphosphate which has been mixed with agricultural lime. In such cases it is this form of lime which should be used and not the kinds mentioned under (*b*) and (*c*).

(*b*) Burned or unslaked lime is obtained by thoroughly burning the carbonate limestone until it has all been converted into calcium oxide which in the pure state ought to contain 100 per cent. CaO. In this form, however, the lime is corrosive, destroying bags in which it is placed and burning the eyes, nose and mouth of those working with it. Consequently it is rather troublesome to handle. Its action on the soil is very drastic and it is therefore recommended only for improving the soil structure as discussed under question (1) (*c*). If burned lime is exposed to the air or moistened it is converted into slaked lime, the chemical process being accompanied by the liberation of a great amount of heat.

(*c*) In its purest form this slaked or hydrated lime $Ca(OH)_2$ should contain 100 per cent. $Ca(OH)_2$ which is equivalent to 75 per cent. CaO, the form in which the chemical composition is generally stated. To some extent slaked lime possesses the same characteristics as unslaked lime but is markedly less caustic. It is usually sold in the form of a fairly fine powder and is presumed to act comparatively rapidly and therefore regarded as better than ground limestone. After long exposure to the air both slaked and unslaked lime partially revert to the carbonate form and consequently mixtures of this

or of partly burned lime are also found on the market. Such lime is more concentrated than the pure carbonate and therefore more expensive. Slaked lime may also be used for improving soil of the type discussed underitem 1 (*c*).

(3) AMOUNT AND METHOD OF APPLICATION

Regarding the quantity required and the method of application the answer to question (3) depends not only on the purpose for which the lime is to be used but also on the nature of the soil, and consequently this can be settled only by actual determination of the lime requirements of such soil. Usually applications for approximately 2 tons of ground limestone or 1 ton of unslaked or slaked lime per morgen repeated every three years are recommended. Where a proper system of rotational cropping is practised lime should always be applied to the crop requiring it most. Since the action of the carbonate is comparatively slow, it should preferably be well ploughed under a few months before planting the crop for which it is intended. On account of the caustic action of burned lime this form of lime also should only be used if several months elapse before the soil is utilized for a crop.

(4) CHARACTERISTICS OF GOOD AGRICULTURAL LIME

In regard to question (4), the farmer should make sure that he purchases the correct kind of lime, that it is reasonably fine, and that the price is in accordance with its actual lime (CaO) content. Fineness is of importance chiefly in the case of the carbonate or ground limestone. This form of lime is not soluble in water, but if it is present as a fine powder the carbon dioxide and moisture in the soil gradually dissolve and "activate" it. Provided it is not coarser than ground coffee it is quite satisfactory, for in this state a sufficient proportion of fine material will be present to ensure a good reaction in the first season. Extreme fineness is no particular recommendation and the statements sometimes made that certain kinds of lime are of a "colloidal" nature (*i.e.*, invisibly fine particles) and therefore superior to other kinds are usually gross exaggerations.

In any case it is really the calcium oxide (CaO) which is the active agent in all kinds of agricultural lime, although it is not denied that the form of combination and the degree of fineness influence their activity. Consequently these figures are also used as the basis for comparing one kind of lime with another especially in regard to the price. For that reason the analysis of all kinds of agricultural lime always shows the percentage of CaO. So, for example, a 100 per cent. calcium carbonate contains 56 per cent. CaO, from which can be calculated that calcium carbonate with, say, 30 per cent. CaO contains only about 53 per cent. carbonate ($CaCO_3$) and therefore 47 lb. of impurity in every 100 lb. of the article. Hence, if a farmer has to choose between two kinds of agricultural lime for which different prices are quoted, he must first make sure of the correct kind which he requires for his purpose. If he decides to use the carbonate form and is satisfied that the degree of fineness is correct he should then obtain the correct figure for the percentage of CaO. The price per ton is then divided by the percentage of CaO and the "unit price" thus obtained. Similarly the unit price of any other lime can be obtained and a comparison made with the first.

By the way of example, let us suppose that the farmer takes the following two advertisements quoting lime at :—

(*a*) £1 per ton containing 50 per cent. CaO ; and
(*b*) £1 10*s*. per ton containing 30 per cent. CaO.

In the case of (*a*,) therefore £1 is divided by 50 when it will be found that the unit price for this lime is about 5*d*., while in the case of (*b*) if £1 10*s*. is divided by 30 the unit price of CaO will be exactly 1*s*. From this it is very obvious that the farmer will be getting much better value for his money if he purchases (*a*).

(5) PROTECTION FOR THE FARMER

With reference to question (5) farmers are reminded that there is a law governing the sale of all fertilizers, stock feeds, seed and stock remedies. In consequence all such articles must regularly be registered with the Department of Agriculture and Forestry, from which farmers can always obtain full particulars. The seller is also obliged to furnish the buyer with a statement giving an analysis of the article which must serve as a guarantee. In addition the bags must be properly marked with his registered name and trade mark. If the farmer has reason to doubt the genuineness of the article he is purchasing, he can avail himself of the protection afforded by this law.

Under these circumstances therefore every farmer ought to know exactly what he is buying, and in the event of his not understanding the figures given in the analysis, he should write to this Department for particulars before making any blind purchase. If, however, the farmer should find it too much trouble to obtain the necessary information in advance and, for example, buys agricultural lime with 30 per cent. CaO for £1 10*s*. per ton when he could have obtained a lime containing 50 per cent. CaO for £1, he has no one but himself to blame, and cannot avail himself of the protection afforded under the above-mentioned or any other act.

CALF REARING*

WHEN milk products are sold, attention should be devoted to every possible source of wastage, which tends to lessen the regular monthly income. The rearing of calves is usually a costly business. Consequently, it is necessary that the minimum quantities of milk on which a calf can be reared normally, without in any way impairing its health, should be known.

A mistake often made in this country is the indiscriminate rearing of every calf born. It would be far more profitable to select for rearing only calves which, in the owner's mind, would justify the time and expenditure involved. Those calves that have no history in regard to production, or whatever quality is desired, should be sold as veal or even destroyed

When a calf is hand-reared, there is no reason why it should not thrive and be in just as good health as the beef calf, which is allowed to run with its dam and suck whenever it feels like it.

Many farms are situated in parts of the country, where there is excellent cattle veld, but no possibility of growing supplementary feed, owing to the low rainfall. Where transport facilities exist in such areas, dairy ranching is generally resorted to with success. It would not be advisable, however, under these conditions to farm with high-producing cows, as they are liable to be milked to death.

Under dairy-ranching conditions, calves are reared in a number of different ways. There is always the temptation to obtain as much milk as possible from the cows, often with irreparable loss as far as health and growth of the calves are concerned.

In some cases calves are allowed to suck only a little before and after milking, and during the day they are grazed in a small paddock. Calves reared under such conditions are stunted and thin as a result of mineral deficiency and a possible protein shortage. It would be advisable to supplement these deficiencies in the form of a lick. The quantity of milk allocated to each calf is often regulated by allowing the calf to have one or two quarters of the udder at each milking. Although this may be described as a step in the right direction, the calf is practically certain to receive an insufficient milk supply. The reason for this statement will be appreciated when one considers the fact that many cows on dairy ranches only produce about one gallon of milk daily, a quantity necessary for a two-weeks-old calf.

In order, therefore that the calf may have a good start in life, it seems advisable to milk only once a day. Greatest success in the raising of calves

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* By Dr. P. J. v. d. H. SCHREUDER, Senior Professional Officer, Glen College of Agriculture and Experiment Station O.F.S. and Dr. J. W. Groenewald, Research Officer, Division of Veterinary Services, Onderstepoort, Transvaal, in *Union of South Africa Department of Agriculture and Forestry Bulletin 224.*

is attained where the calves are separated from their dams in the evening, and the cows milked the following morning. During the day, the calves should be allowed to run with the cows in the veld. Small calves are capable of walking remarkably long distances; in fact, herdboys usually find it difficult to manage a herd of cows with their calves. For these reasons, and because of transport conditions, some dairymen prefer to milk in the evenings, the calves being shut up in the kraal during the day. It may be pointed out, however, that calves which run with the cows during the day will learn to graze the natural veld at an early age.

Calves should be adequately supplied with fresh, clean water at all times. Water from frozen troughs, however, as is often seen during winter, is definitely harmful to calves and young stock.

Under dairy-ranching conditions, calves should be supplied with phosphatic supplements at an early age. These animals do not receive the quantity of milk and additional concentrate supplements usually fed where calves are hand-reared. Phosphorus may be supplied, either in the form of licks or dosed to the animals daily. The daily quantities to be dosed are 3 ounces of bone-meal or 2 ounces of degelatinized bone-flour, or 1 ounce of di-calcium phosphate, placed on the back of the tongue with a spoon. The two last-named substances should be moistened with water before being administered. Licks are mixed in the following proportions by weight: 3 parts of bone-meal and 1 part of salt, or, 2 parts of degelatinized bone-flour and 1 part of salt, or 1 part of di-calcium phosphate and 1 part of salt.

When di-calcium phosphate is used, a guarantee should be obtained from the seller as to the fluorine content of the substance. If the fluorine content of di-calcium phosphate exceeds 0·5 per cent., it may prove harmful to animals.

The present high standards of maximum milk production have created a cow giving quantities of rich milk much in excess of the normal requirements of the calf. It would, therefore, be unwise, from a health point of view, to allow a calf from such a cow to gorge itself with milk. The digestive system of the young calf is very sensitive to changes of diet, quantities of feed, dirt, and changes of temperature. Hence, it is at all times necessary to be absolutely punctual and very precise in the matter of feeding. Strict adherence to the factors just mentioned will ensure a happy, "flashy" calf, whose unstunted growth will soon repay the extra attention given to its feeding and management.

In urban areas, whole milk is generally retailed, the result being that no skimmed milk is available for calf-rearing. In some instances such dairymen resort to nurse-cows with success.

CARE OF THE COW

It is desirable that the cow should be in a good physical condition prior to calving, in order to ensure a healthy calf. The cow should be dried off 6 to 8 weeks before calving time. During this "dry" period she should receive a good, fairly nutritious and laxative ration. The nutritive requirements of the foetus for the greater part of the gestation period are naturally small, yet it is necessary to supply the cow with an adequate supply of feed to build a well-developed calf. Failure to give a good cow the needed rest results in her having to start the next lactation in too low a condition. The feeding problem of a

cow that is due to calve is practically solved where she has access to good grazing. If the cow is low in condition, she should receive, in addition to pasture, 4 or 5 lb. of grain daily. A good grain mixture may be made up from equal parts of maize-meal, wheaten bran and ground oats. If no grazing is available, it is essential to supply the cow with some silage or green feed, in order to provide a laxative ration. About a week before calving, the grain ration may be reduced or completely withdrawn. A few feeds before calving may consist of a wet mash of equal parts of ground oats and bran, mixed with warm water. Every effort must be made to keep the cow from becoming constipated, as this increases the possibility of difficulty at calving.

Exercise is essential to the dry cow. A 2-gallon (16 to 20 lb.) cow should not take longer than 2 weeks to dry off. A good plan is to keep such a cow in the byre—if she is accustomed to graze, but off her grain ration—and give hay only. Milk only once daily for the first four days, then relieve the udder every other day for a period of about a week. In this connexion it is wise to be careful, but the farmer should not be unduly alarmed, for unless the udder has some defect, no harm will result. When the udder is dry and in a good pliable condition, feeding may be resumed.

CARE OF THE CALF

Provision should be made for the calf to be born in sanitary quarters. The pen must be clean, light, well-ventilated, and comfortable. In order to avoid infection with any of the calf diseases, the pen should be cleaned and lime and dip used on the floor, as well as clean straw put down for bedding. It is advisable to allow the cow to occupy the calving pen for a few days prior to calving. Weather conditions generally favour outdoor calving in this country. This is desirable, provided that the cow calves in a clean grassy paddock. During the ordeal of calving, careful and prompt attention may be necessary. Experience enables one to gauge fairly closely when the calf will come. The pronounced loosening of the vulva and the "falling away" on either side of the tail setting are fairly reliable indications that calving is near. Another reliable guide is the filling and distention of the teats. During calving, the cow should be disturbed as little as possible. A cow should calve down within an hour of onset of parturition.

If the cow has calved normally, she will immediately lick her calf. This act assists in drying the calf and starting respiration, and also helps the blood circulation. Should foetal membranes cover the nostrils, these must be removed promptly. It is always desirable immediately after birth to wash and disinfect the navel of the new-born calf with a disinfectant such as tincture of iodine or carbolic acid.

A strong calf will usually attempt to rise in about 15 or 20 minutes, and will be nursing within about half an hour. If, after an hour, the calf has not had a drink, it may be advisable to give it some assistance. It is essential that the calf get the first milk or colostrum, which has special laxative properties as well as additional qualities which are necessary to start the new-born calf on its career. Colostrum, for instance, has the property of providing the calf with certain anti-bodies which fortify the animal against the many infections liable to occur at this delicate age. Occasionally, when the calf fails to receive

the first milk or colostrum from its dam, the meconium is retained, because the bowels remain inactive. In this case a teaspoonful of castor oil may be given at frequent intervals until there is a movement of the bowels.

TEACHING THE CALF TO DRINK

The calf may be separated from the cow immediately after having had its first drink, or it may be allowed to remain with its dam for one or two days. If the udder is much inflamed frequent sucking by a calf is undesirable. If left together longer, both the cow and the calf will be more disturbed when they are finally separated. Most calves will learn to drink in a few minutes, especially if they are hungry. The best method is to allow the calf to suck one's fingers ; the hand can be gradually lowered into the bucket and submerged in the milk sufficiently deeply to allow a little of the milk to be taken by the calf. The fingers can then be withdrawn gradually so as not to arouse suspicion. One lesson may suffice, but if it does not, the procedure must be repeated until the calf will drink from the bucket on its own. Here success comes only with patience.

THE WHOLE-MILK PERIOD

As already mentioned, the hand-rearing of calves is in the best interests of both calf and dairyman, yet it is not always an easy task and is perhaps most conscientiously carried out by older men. Some dairymen are inclined to favour the use of nurse-cows. This method of raising calves has its possibilities, provided cows of a suitable type are obtainable, and that the number of calves allotted to each cow is such that they all get sufficient milk. For instance, one quarter of an old cow producing 4 gallons of milk daily could be given to each of four calves. This question, however, must be left entirely to the discretion of the farmer.

It is naturally desirable, for economic reasons, to have the whole-milk period as short as possible. Nevertheless, best results are always obtained when conditions approximate to those of Nature. It has been shown that if there is 3 to 5 per cent. of butterfat in milk it passes more easily through the digestive tract than does skimmed milk.

When the calf is taken away from its dam, it should not be over-fed. There is generally more risk of over-feeding at this stage than there is of under-feeding. A useful rule is to give the calf approximately 1 lb. of milk daily for every 10 lb. of its weight.

The birth weights of calves are approximately as follows :—Ayrshire, 66 lb. ; Guernsey, 64 lb. ; Friesland, 94 lb. ; Jersey, 54 lb. Calves of all mixed breeds may, as a rule, be taken to weigh approximately 70 lb. at birth.

A Jersey calf weighing 54 lb. would therefore be given about 5·5 or, for ease, 6 lb. of milk per day, whereas the 94 lb. Friesland may get as much as 10 lb. The milk must be fed at about body heat. Best results are obtained when calves are fed 3 times a day at this stage. The general practice among many dairymen is to feed twice daily from the outset. It is necessary that feed buckets should be scalded and kept in a clean place after feeding. Irregularities, such as unhygienic utensils, may result in dirty and sour milk, which, in turn, is a certain cause of scours.

In ordinary circumstances the whole-milk period lasts for 3 weeks. The increase in milk fed from the first day is about ½ lb. every second day, until the calf is 3 weeks old.

THE SKIMMED-MILK PERIOD

When a calf has been on whole milk for 3 weeks, skimmed milk is substituted for the whole milk. The change from whole milk to skimmed milk should take place gradually. The procedure usually adopted is to replace 1 lb. of whole milk by 1 lb. of skimmed milk daily until, after a week or ten days, the calf is entirely on skimmed milk. As a rule, calves are fed skimmed milk until they reach the age of 6 months. Buttermilk or whey may to some extent take the place of skimmed milk. Both these feeds, however, are often stored in dirty containers.

It must be borne in mind that these substances are derived from mixed milks at creameries, and are liable to be infected with tubercular bacilli or other pathogenic organisms. Buttermilk is further unreliable in that it often contains excessive amounts of wash water. Whey, on the other hand, lacks the protein which is present in buttermilk or skimmed milk. When whey is used success can be obtained only by inducing the calves to take a portein supplement in the form of a grain mixture. The following grain mixture may be fed along with whey and a legume hay : 3 parts of ground maize and 3 parts of linseed-oil meal. Dried skimmed milk is expensive in this country, but where it is obtainable it is mixed with water, and fed. One part of dried skimmed milk is added to 9 parts of water, and is then equal to 10 parts of ordinary skimmed milk.

When skimmed milk forms the major feed, Table I may be used as a guide :—

Table 1.—Rearing Calves on Skimmed Milk

Age of calf.	Whole milk. lb.	Skimmed milk. lb.	Grain. lb.	Hay. lb.
1 to 2 days	With dam	—	—	—
2 to 14 days	5 to 10	—	—	—
2 to 3 weeks	10 tp 1*	1 to 10*	⅓	free access
3 to 4 weeks	—	10	¼	,,
4 to 5 weeks	—	11	½	,,
5 to 6 weeks	—	12	¾	,,
6 to 8 weeks	—	13	1	,,
8 to 12 weeks	—	14	2	,,
12 to 24 weeks	—	16	3	,,

* In the first case the whole milk is gradually decreased, while the skimmed milk is increased accordingly. Where dairy farming is practised successfully, a milk scale becomes an essential. On the farm a gallon is taken to represent 10 lb.

WHERE ONLY A LIMITED QUANTITY OF WHOLE MILK IS AVAILABLE

It frequently happens that calves have to be reared on a limited quantity of whole milk because no skimmed milk is available. In this case it should be remembered that the secret of success lies in giving the calves a good start on whole milk. At the same time, they should receive every possible encouragement to eat grain and hay. The whole-milk requirements of Friesland calves reared in this manner, according to Mr. C. A. Murray, Matopos School of Agriculture, Southern Rhodesia, are given in Table II.

Another method of raising calves on a minimum quantity of whole milk is to give a milk substitute. No such substitute can, however, take the place of milk with entire satisfaction. The calf meals or gruels are not as easily digested as milk, with the result that digestive disturbances are more common. A simple gruel may be mixed, in equal parts by weight, as follows :—Linseed-meal, blood-meal and pollards.

Table 2.— Raising Friesland Calves on a Limited Quantity of Whole Milk

Period in days.	Period in weeks.	Whole milk per calf daily.
1st day, with dam	—	—
2nd day, dam's milk	—	4 pints
3rd to 7th day, dam's milk	—	6 ,,
	2nd week	8 ,,
	3rd ,,	10 ,,
	4th ,,	10 ,,
	5th ,,	12 ,,
	6th ,,	10 ,,
	7th ,,	8 ,,
	8th ,,	6 ,,
	9th ,,	4 ,,
	10th ,,	2 ,,

One part of the above gruel mixture is mixed with 8 parts of water and brought to the boil. The gruel is then allowed to cool, but it should always be fed at body heat. Where gruel is used as the major feed, calves may be fed as shown in Table 3.

Table 3.—Feeding Gruel to Calves

Age of calf.	Milk. lb.	Gruel. lb.	Grain. lb.	Hay. lb.
1 to 2 days	with dam	—	—	—
2 to 14 days	10	—	—	—
2 to 3 weeks	9	1	—	—
3 to 4 weeks	9	3	$\frac{1}{8}$	free access
4 to 6 weeks	6	6	$\frac{1}{4}$	,,
6 to 8 weeks	—	12	$\frac{1}{2}$	,,
8 to 12 weeks	—	14	1	,,
12 to 16 weeks	—	14	2	,,
16 to 20 weeks	—	—	4	,,

The quantity of milk or gruel given depends largely on the size or weight of the calf. Jersey calves, for instance, will be found to thrive better on half the quantities given in Tables 2 and 3 especially if they are fed only twice daily. The condition of the faeces should always be carefully watched, and the milk reduced in case of diarrhoea.

THE FEEDING OF GRAIN AND HAY

There is considerable doubt as to the desirability of allowing a calf roughage at too early an age. Calves will be seen to nibble at feeds when they are only a few days old. A few handfuls of grain and a little hay may be given in order to induce them to eat. At 3 weeks calves will consume approximately the quantities given in the accompanying tables. These are only approximate guides and should be followed with discretion. Calves should be fed so that

their mangers are always clean. They relish whole grain. Whole maize or oats may be given. It may also be desirable to feed bran or oil-meal, but never feed cotton-seed meal to calves. A mixture that has given excellent results is : 3 parts of ground maize, 3 parts of crushed oats, 1 part of bran and 1 part of linseed-oil meal. This grain mixture may be modified to some extent, with equally satisfactory results. The main thing is to watch for digestive disturbances. If these occur, the grain mixture will either have to be cut down or changed. Perhaps all that will be necessary is to give less lucerne hay. Bran and oil-meal are desirable on account of their added phosphorus and protein content, as well as laxative effect.

Feeders differ as to the desirability of silage for young calves. There is no danger, however, as long as calves consume all the silage before them. Danger of scours occurs only when silage has been allowed to accumulate in the mangers, or when it is mouldy. When calves are properly fed, there is no need for them to be let out to pasture. Pasturing inadequately fed calves on poor veld before they have reached the age of 6 months tends to make them paunchy. However, they should at all times receive sun and exercise.

Calves should always have free access to fresh clean water. An abundant milk supply does not make up for the water that a calf requires.

If calves are reared along the lines prescribed above until they are 6 months old, no mineral supplement will be necessary. Serious consequences may be expected should a nutritional deficiency occur during the first six months of the calf's life. The ration should be such that the calves will make at least normal growth for the breed, which, according to the Missouri Research Station, is given in Table 4.

Table 4.—Normal Weight and Height at Withers of Females

Age (Months)	Frieslands.		Jerseys.		Ayrshires.	
	Height Inches.	Weight. lb.	Height. Inches.	Weight. lb.	Height Inches.	Weight. lb.
Birth	28·3	90	26·0	55	—	69
1	30·2	121	27·7	76	27·5	90
2	32·3	157	29·4	105	29·5	128
3	34·2	200	31·2	140	31·2	170
4	36·2	249	32·9	174	33·1	218
5	38·0	302	35·1	222	35·1	254
6	39·7	349	36·9	260	36·4	286
7	40·9	389	38·1	302	37·3	304
8	42·2	425	39·3	350	38·5	336
9	42·9	466	40·5	376	39·0	366
10	43·8	501	41·3	407	39·6	406
11	44·3	529	41·9	432	40·1	427
12	44·8	558	42·6	456	40·7	456
13	45·6	574	43·3	480	41·3	485
14	46·2	596	43·8	503	42·0	533
15	46·8	612	44·4	520	42·4	547
16	47·4	643	44·6	533	42·7	560
17	47·7	660	45·1	553	43·1	579
18	47·9	686	45·5	572	43·7	604
19	48·3	715	46·0	598	44·2	627
20	48·7	746	46·3	621	44·6	651
21	48·9	774	46·5	649	44·9	679
22	49·2	796	46·8	668	45·4	707
23	49·5	824	47·2	689	45·6	733
24	49·8	841	47·4	716	45·9	759

COMMON CALF TROUBLES

When calves have had their milk feed, they will invariably start sucking each other. This vice often becomes serious, for not only is hair swallowed, but udders, navels and scrotums may be damaged. A good plan is to feed the grain mixture after the calves have finished their milk. Cheap but effective wooden stanchions are often employed to prevent this vice, and they make the feeding of calves safe and easy. These are made by bolting uprights, 6 inches apart, to a horizontal beam placed along the ground. A second horizontal beam placed along the ground. A second horizontal beam about 4 feet high, completes the stanchion, every second upright being left loose on the upperbeam, so that it acts scissors-like, and the head of the calf may easily be secured.

More calves are stunted because of common scours than through insufficiency of feed. This defect is liable to occur under the best feeding conditions. The most frequent cause of common scours is over-feeding. Hence, it is always essential to reduce the feed. Good results have been obtained by reducing the milk feed to half the daily supply. Water is then added to the milk, making the feed up to 1 part of milk and 1 part of water. The calf may be fed on water and milk until improvement is noticed. The quantity of water is then gradually diminished and replaced by milk, until the calf is on its regular quantity of milk. The usual method of treating calves that have common scours, is to give them a dose of 1 to 3 ounces of castor oil. A tablespoon of lime-water may also be added to each quart of milk.

The addition of pure lime (calcium carbonate) as a routine procedure at each feeding period has given excellent results, and is a good preventive measure against scours.

Flies often abound in calf pens and where calves are fed. Many fly repellants may be used, but the greatest success is usually attained by applying preventive measures. Flies hatch in wet and damp places, or in the droppings of animals. The best methods of dealing with flies is therefore to keep the surroundings clean and dry.

HUMUS AND SOIL EROSION*

ONE of the most beneficial properties of humus in soil is its capacity to absorb and retain water, thereby restricting erosion. This characteristic is of the greatest importance to the farmer in his struggle against soil erosion.

The lack of humus in arable lands manifests itself in the ease with which dongas are formed, the compacting of the soil and formation of a hard crust after every shower of rain, the rapid desiccation of the soil and the poor absorption of rain in comparison with the amount precipitated. This lack of humus results in poor germination and growth of crops, and relatively poor yields even though fertilizer is applied.

In many cases this deterioration is the direct result of continuous intensive cultivation of the soil without giving it an opportunity to lie fallow so as to make possible the accumulation of organic matter in the form of grass, shrubs, &c., in the form of humus or in order that the soil may be enriched by the ploughing under of green manure, straw, stable-manure, &c.

The difficulty may be largely met by allowing permanent pasture grasses to occupy a definite place in the crop-rotation system of the farm. The good vegetal cover of land planted to such pasture grasses will reduce run-off to a minimum while incessant combustion of vegetable and animal matter as a result of continuous cultivation of the soil is also eliminated. The dung of animals grazing on such grasses is beneficial, and a mass of material in the form of leaves, stalks and roots is available for conversion into humus.

The problem of soil erosion affects not only cultivated lands but also natural grazing where this evil may perhaps have even more serious consequence. Erosion, desiccation and poor plant growth are also encountered in the natural veld and are the direct result especially of overstocking, trampling out and burning of the veld which prevent any plant material from being available for conversion into humus. Soil-erosion works can yield the desired results only when an improvement is effected in the physical structure of the soil so that water made available can be absorbed and retained. This capacity can be increased considerably when sufficient quantities of vegetable and animal matter are introduced in the soil. Consequently it is essential that overstocking, trampling out and burning of our natural grazing should be eliminated immediately and that a system of grazing should be applied in which the natural pasture plants can develop to the fullest extent so that as much organic matter as possible may be returned to the soil in the form of humus.

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* By J. C. S. Brandt, Extension Officer, Smithfield, in the *Farming in South Africa*, Vol. XVI.—No. 184, July, 1941.

CORRESPONDENCE

112, Barnes place,
Colombo, October 10, 1941.

The Editor,
Tropical Agriculturist,
Department of Agriculture,
Peradeniya.

The Premature Fall of Coconuts.

SIR,

THE subject of your Editorial in the May Issue of the *Tropical Agriculturist* should be of immense interest to all practical coconut planters, and of concern to others.

Your invitation for suggestions from the public gives me inducement to write on the subject, and I thank you for further information supplied.

Your first suggestion of inadequate moisture being one of the causes, has a very important bearing on the whole question, while that of fungus disease may, for the present, be left alone in view of the many experiments carried out without success.

The graph to show the average rate of nutfall per palm side by side with the rainfall for that period is a right step taken to arrive at the root cause of the trouble, with your Chemist, perhaps to follow up and check unusual deficiencies or accumulations in the soil during periods of dry weather and when the water table is low, and when the reverse takes place.

It is not clear whether the numbers given represent nuts of all ages. If the figures represent buttons only it then clearly shows the effect of the moisture content in the soil at the time the spathes open.

Estate owners who appreciate records and keep them will know that, when the rainfall is below normal for a certain period, the crops for that corresponding period 12 months later are low. Similarly the reverse is the case when the rainfall has been normal. Estates in the Puttalam District, and I should say in a good many other areas, will afford proof from the crops harvested this year as a result of last year's well-distributed rainfall.

Having had the opportunity to examine rainfall and crop figures on a great many coconut estates, particularly in the North-Western Province, during the past two decades, I am satisfied that this contention is not without foundation.

It may thus be concluded and I am strongly of opinion that rainfall about 12 months back from harvest has a direct bearing on the question of abscission of immature nuts in the button stage. There might have been an abnormal drought or heavy rainfall before the spathes of harvested crops opened, or when the young female flower was ready for pollination.

The extent of nutfall and the final decrease or increase in crops is also controlled by the degree and nature of the cultivation given to the land during these periods. We often hear that light showers following a drought cause tender nuts and buttons to fall, and this is being experienced at the present moment in areas known as the dry zone. Planters may also have experienced serious nutfall following the application of mineral manures when the rainfall that was expected to follow was on the short side. It is also to be noted that the rate of nutfall on land that receives no cultivation is greater than on land which receives regular cultivation during periods of prolonged dry weather.

There is also the fact that the area available in the root system for the absorption of soil moisture is very much reduced by reason of the fact that the hypodermis continues to grow during periods of drought and reduces the area of epidermis, immediately behind the tip of the root, through which the water is taken. Therefore all these factors such as cultivation, application of mineral manures, dry weather, excessive rainfall, starvation, strong winds, and last but not least, the inherent defect in the palm to cause its immature nuts and buttons to fall, are all contributary causes.

The slogan therefore is to cultivate your land regularly (I use this in its widest sense) and return everything that is not wanted back to the land by burying, instead of adopting the wasteful method of burning, unless it is to get some potash. When possible, make your own compost and apply it to your land in large quantities. Well made compost will give you as complete a mixture as you can wish to have now at very little cost. More than half this cost of making compost is incurred on an average estate in its daily routine but allowed to go to utter waste. Such methods will help to produce 2 to 2½ thousand nuts per acre in the Western Province and similar soil, and 2½ to 3½ thousand or over in the North-Western Province. When this is reached one need not worry about nutfall, which under some few circumstances I do not think can be avoided.

I regret the long delay in sending you this.

Yours faithfully,

MARCUS S. ROCKWOOD

[The figures referred to in paragraph 5 relate to records taken of nuts other than button nuts.—Ed., *T.A.*]

ANIMAL DISEASE RETURN FOR THE MONTH ENDED 30TH SEPTEMBER, 1941

Province, &c.	Disease	No. of Cases up to date since January 1, 1941	Fresh Cases	Deaths	Recoveries	Balance ill	No. shot
Western	Foot-and-mouth disease	73	71	1	28	44	..
	Piroplasmosis	1	..	..	1	..	..
	Rabies	19	4	7	..	..	12
Colombo Municipality	Foot-and-mouth disease	860	803	..	621	239	..
	Rabies	38	1	38	..	..	..
	Hæmorrhagic Septicæmia	1	..	..	1	..	..
Cattle Quarantine Station	Foot-and-mouth disease	5	5	..	5	..	..
	Anthrax	8	..	8	..	..	..
Central	Foot-and-mouth disease	5	3	..	2	3	..
	Piroplasmosis	4	..	1	3	..	..
	Rabies	51	2	9	..	..	42
	Bovine Tuberculosis	6	..	..	..	..	6
	Contagious Abortion	1	..	..	..	..	1
	Blackquarter	12	12	12	..	..	..
Southern	Foot-and-mouth disease	43	..	2	41	..	..
	Rabies	13	1	..	..	..	13
	Hæmorrhagic Septicæmia	53	..	53	..	..	..
Northern	Foot-and-mouth disease	248	..	..	248	..	..
Eastern	Foot-and-mouth disease	65	..	6	59	..	..
	Goat pox	4	4	1	..	3	..
	Rabies	12	4	..	..	..	12
North-Western	Mange	9	1	1	7	1	..
	Anthrax	24	..	24	..	..	..
	Rabies	9	1	..	..	..	9
	Piroplasmosis	3	2	2	1	..	..
North-Central	Hæmorrhagic Septicæmia	43	..	43	..	..	..
Uva	Anthrax	31	31	31	..	..	..
	Blackquarter	13	..	13	..	..	..
Sabaragamuwa	Piroplasmosis	4	..	..	4	..	..
	Rabies	6	..	3	..	..	3

Department of Agriculture,
Peradeniya, October 25, 1941.

M. CRAWFORD,
Deputy Director (Animal Husbandry) and
Government Veterinary Surgeon.

METEOROLOGICAL REPORT, SEPTEMBER, 1941

STATION	TEMPERATURE				HUMIDITY		Amount of Cloud	RAINFALL		
	Mean Maximum	Difference from Average	Mean Minimum	Difference from Average	Day	Night (from Minimum)		Amount	No. of Rainy Days	Difference from Average
	°	°	°	°	%	%		Ins.		Ins.
Agalawatta ..	84·1	—1·6	73·0	—0·3	82	93	6·8	26·32	28	—
Anuradhapura ..	92·1	+0·9	75·6	+0·7	62	91	6·8	2·78	9	— 1·13
Badulla ..	85·4	—0·4	66·1	+1·9	66	92	6·2	7·16	13	+ 2·68
Batticaloa ..	88·9	—0·7	77·2	+1·2	66	80	5·4	1·99	6	— 0·56
Colombo ..	85·5	+0·2	76·3	—0·3	75	84	8·0	9·46	27	+ 2·45
Diyatalawa ..	78·0	0	62·1	+1·4	70	89	6·5	4·30	17	— 0·10
Galle ..	83·0	+0·1	76·7	—0·2	83	86	7·3	17·20	25	+ 6·80
Hakgala ..	70·2	—0·4	58·1	+1·9	82	86	7·0	7·14	19	+ 0·57
Hambantota ..	86·0	—0·4	76·5	+0·4	79	88	6·7	4·38	14	+ 1·32
Jaffna ..	86·0	0	78·8	—0·3	79	86	5·6	8·70	7	+ 5·61
Kandy ..	84·4	+0·3	69·1	—0·1	78	92	8·1	4·66	20	— 1·93
Kurunegala ..	86·8	—0·8	74·6	+0·5	77	90	8·1	7·32	20	+ 1·15
Lunuwila ..	85·9	—0·3	75·6	—0·7	81	95	7·2	7·71	21	—
Mannar ..	86·9	—1·1	78·7	—0·1	75	84	8·2	3 78	4	+ 2·45
Nuwara Eliya ..	67·5	+0·3	54·0	+1·2	83	94	8·8	4·97	24	— 3·96
Puttalam ..	88·0	+1·4	78·7	+1·1	74	84	6·6	0·86	5	— 0·93
Ratnapura ..	86·3	—1·0	74·4	+1·0	83	95	7·7	21·69	28	+ 5·41
Talawakele ..	73·3	+1·1	59·4	+1·3	82	94	8·8	7·89	21	— 2·29
Trincomalee ..	91·2	—0·4	76·7	—0·2	65	86	4·2	8·30	9	+ 4·48

The rainfall for September was generally above average in the north, south-west and south of the Island. Deficits predominated in the central hill-country. Slight excesses also occurred in small areas to the north-east and east of the central hills, and around Trincomalee on the east coast.

The largest excesses were 15·90 inches at Sunderland, 15·38 inches at Beausejour, 15·35 inches at Marambekanda, 15·30 inches at Ruwanwella and 15·18 inches at Geekiyanakanda, nearly all in the western and south-western mid-country. About a dozen other stations in the same areas also recorded excesses of over 10 inches.

The largest deficits were 5·57 inches at Onoogal-oya, 5·33 inches each at Hatton and Blair Athol and 5·27 inches at Westward Ho.

The largest monthly totals were Kottawa 37·00 inches, Dabar 33·64 inches, Udugama 33·54 inches and Sunderland 32·38 inches. Nine other stations also received rainfall totals of over 30 inches.

Altogether 16 daily falls of over 5 inches were reported, nearly all of them on the 30th, the largest being 8·70 inches at Marambekanda.

The weather during September gave clear evidence of the effect of a weakening south-west monsoon. Although for the most part a moderate south-westerly pressure gradient prevailed during the month, there were occasional periods of comparatively even pressure distribution, allowing the development of local circulations and the resulting thunderstorms. The rainfall was fairly well distributed in time, the only comparatively dry period being the 21st-26th.

Temperatures were irregularly distributed on either side of average by day, and were generally above average by night. The highest shade temperature recorded was 95·2° at Batticaloa on the 8th, while the lowest temperature was 47·8° at Nuwara Eliya on the 13th and 25th. Humidities were above average during the month, and cloud amounts were in excess. Surface winds were on the whole about average, the predominant direction being south-westerly.

D. T. E. DASSANAYAKE,
Superintendent, Observatory.